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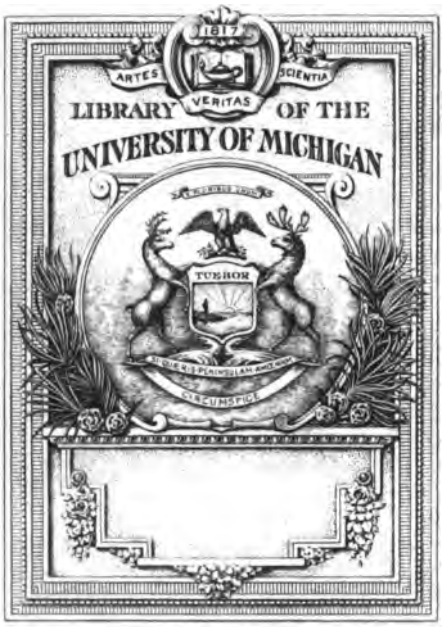
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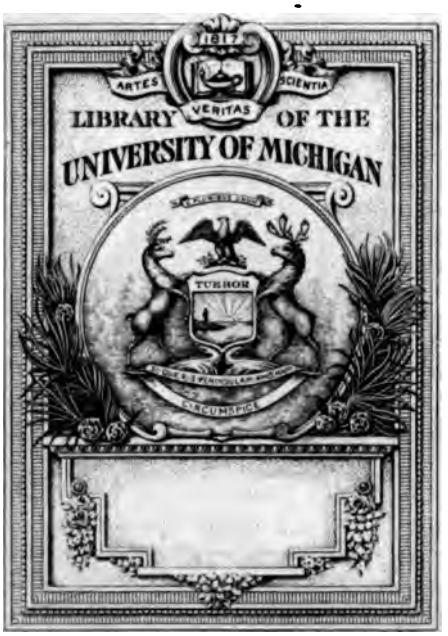
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BULLETIN

OF THE

UNITED STATES FISH COMMISSION.

VOL. X,

FOR

1890.

MARSHALL McDONALD, Commissioner.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1892.

Joint Resolution authorizing the Public Printer to print Reports of the United States Fish Commissioner upon new Discoveries in regard to Fish-culture.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Public Printer be, and he hereby is, instructed to print and stereotype, from time to time, any matter furnished him by the United States Commissioner of Fish and Fisheries, relative to new observations, discoveries, and applications connected with fish-culture and the fisheries, to be capable of being distributed in parts, and the whole to form an annual volume or bulletin not exceeding five hundred pages. The extra edition of said work shall consist of five thousand copies, of which two thousand five hundred shall be for the use of the House of Representatives, one thousand for the use of the Senate, and one thousand five hundred for the use of the Commissioner of Fish and Fisheries.

February 14, 1881.

TABLE OF CONTENTS.

Page.

Bean, Tarleton H. (editor). Observations upon Fishes and Fish-Culture..... 49–61

Battle, John D. An Investigation of the Coast Waters of South Carolina with reference to Oyster-Culture..... 303–330

Collins, J. W. The Fishing Vessels and Boats of the Pacific Coast 13–48

Collins, J. W., and Hugh M. Smith. Report on the Fisheries of the New England States.... 73–176

Dean, Bashford. The Physical and Biological Characteristics of the Natural Oyster-Grounds of South Carolina..... 335–361

——— ——— The Present Methods of Oyster-Culture in France 363–388

Kellogg, James L. A Contribution to our Knowledge of the Morphology of Lamellibranchiate Mollusks..... 389–436

Kirsch, Philip H. Notes on the Streams and Fishes of Clinton County, Kentucky, with a Description of a New Darter 289–292

Meek, Seth Eugene. Report upon the Fishes of Iowa, based upon Observations and Collections made during 1889, 1890, and 1891..... 217–248

Seal, William P. Observations on the Aquaria of the U. S. Fish Commission at Central Station, Washington, D. C 1–12

Smith, Hugh M. Notes on Fishes from the Lower Potomac River 63–72

——— ——— Report on the Fisheries of Lake Ontario 177–215

Woolman, Albert J. Report upon the Rivers of Central Florida tributary to the Gulf of Mexico, with lists of Fishes inhabiting them..... 293–302

——— ——— Report of an Examination of the Rivers of Kentucky, with Lists of the Fishes obtained..... 249–288

Worth, S. G. Observations on the Hatching of the Yellow Perch 331–334

LIST OF ILLUSTRATIONS.

OBSERVATIONS ON THE AQUARIA AT CENTRAL STATION.

Page.

PLATE I.—Entrance to Marine Grotto 1
II.—Interior View of Marine Grotto 2
III.—Ground Plan of Marine Annex 12
IV.—Auxiliary Aërating Apparatus, Marine Aquaria 12

FIGURES IN TEXT:

FIG. 1.—Eggs of the Tessellated Darter (*Boleosoma olmstedi*) spawned in Aquaria 9
2.—Fresh-water Mussel throwing off the Young 11

FISHING VESSELS AND BOATS OF THE PACIFIC COAST.

PLATE V.—Steam whaling bark Mary and Helen, of New Bedford 13
VI.—Fur-sealing Boat: (1) Body Plan. (2) Half-breadth Plan. (3) Sheer Plan 17
VII.—Washington Dugout Canoe: (1) Sheer Plan. (2) Plan of Top. (3) Cross-section 19
VIII.—Bidarkas: (1) Sheer Plan of Single-hole Bidarka; (1*a*) Cross-section. (2) Sheer Plan of Two-hole Bidarka; (2*a*) Cross-section. (3) Sheer Plan of Three-hole Bidarka; (3*a*) Cross-section 27
IX.—Types of Alaskan Kaiaks: (1) Kaiak from King's Island; (1*a*) Cross-section. (2) Kaiak from St. Michael's; (2*a*) Cross-section. (3) Kaiak from Cape Espenberg; (3*a*) Cross-section 29
X.—Kaiaks and Oomiak: (1) Kaiak from Cape Krusenstern; (1*a*) Cross-section. (2) Kaiak from Point Barrow; (2*a*) Cross-section. (3) Alaskan oomiak or bidarrah; (3*a*) Cross-section of oomiak, showing construction 31
XI.—Alaskan Salmon Fleet at Hyak Bay 35
XII.—Columbia River Salmon Boat 39
XIII.—San Francisco Fishing Felucca: (1) Sheer Plan. (2) Half-breadth Plan. (3) Half-deck Plan 41
XIV.—San Francisco Fishing Felucca: (1) Body of Plan. (2) Midship Section below Deck, showing Construction. (3) Sail Plan 43
XV.—(1) Oyster Sloop, Shoalwater Bay. (2) Fishing Junk 45
XVI.—Chinese Shrimp Boat 47
XVII.—Squid Skiffs, Monterey 48

FIGURES IN TEXT:

FIG. 1. Sail Plan of Alaskan Schooner 17
2. Alaskan Dugout Canoe 21
3. Alaskan Dugout Canoe 23
4. Salmon Dory 45

NOTES ON FISHES FROM THE LOWER POTOMAC RIVER.

PLATE XVIII.—(1) *Cyprinodon variegatus*, male. (2) *Cyprinodon variegatus*, young. (3) *Zygonectes lucia* 72
XIX.—(1) *Fundulus majalis*. (2) *Fundulus diaphanus*, male. (3) *Fundulus diaphanus*, female. (4) *Fundulus heteroclitus* 72
XX.—(1) *Gambusia patruelis*. (2) *Menidia beryllina*. (3) *Paralichthys dentatus* 72

FISHERIES OF LAKE ONTARIO.

		Page.
PLATE XXI.	*Acipenser rubicundus.* Lake Sturgeon	216
XXII.	*Amia calva.* Dogfish; Mudfish	216
XXIII.	*Ameiurus vulgaris.* Bullhead	216
XXIV.	*Catostomus teres.* Common sucker; Brook sucker; Mullet	216
XXV.	*Moxostoma anisurum.* Carp mullet	216
XXVI.	*Cyprinus carpio.* Leather carp	216
XXVII.	*Semotilus atromaculatus.* Horned dace; Chub	216
XXVIII.	*Hiodon tergisus.* Moon-eye	216
XXIX.	*Clupea pseudoharengus.* Alewife; Branch herring	216
XXX.	*Clupea sapidissima.* Shad	216
XXXI.	*Clupea chrysochloris.* Skipjack	216
XXXII.	*Dorosoma cepedianum.* Mud shad; Gizzard shad	216
XXXIII.	*Coregonus clupeiformis.* Common whitefish	216
XXXIV.	*Coregonus artedi.* Lake herring	216
XXXV.	*Coregonus hoyi.* Hoy's whitefish; Lake Moon-eye; Long-jaw	216
XXXVI.	*Coregonus quadrilateralis.* Round whitefish; Menominee whitefish	216
XXXVII.	*Coregonus tullibee.* Tullibee; Mongrel whitefish	216
XXXVIII.	*Salmo salar.* Atlantic salmon	216
XXXIX.	*Salvelinus namaycush.* Lake trout; Salmon trout	216
XL.	*Esox lucius.* Pike; Pickerel	216
XLI.	*Esox nobilior.* Muskellunge	216
XLII.	*Pomoxis sparoides.* Strawberry bass; Calico bass	216
XLIII.	*Ambloplites rupestris.* Rock bass	216
XLIV.	*Micropterus salmoides.* Large-mouthed black bass; Oswego bass	216
XLV.	*Micropterus dolomieu.* Small-mouthed black bass	216
XLVI.	*Perca flavescens.* Yellow perch	216
XLVII.	*Stizostedion vitreum.* Wall-eyed pike: Dory; Pike perch	216
XLVIII.	*Stizostedion canadense.* Sauger; Sand pike	216
XLIX.	*Aplodinotus grunniens.* Sheepshead; Fresh-water drum	216
L.	*Lota maculosa.* Ling; Burbot; Lawyer; Fresh-water cusk	216

REPORT UPON AN EXAMINATION OF THE RIVERS OF KENTUCKY.

PLATE LI.	(1) *Opsopœodus emiliæ.* (2) *Opsopœodus bollmani.* (3) *Etheostoma spilotum*	288

THE STREAMS AND FISHES OF CLINTON COUNTY, KENTUCKY.

FIGURE IN TEXT:

FIG. 1.	*Etheostoma obeyense*	292

THE RIVERS OF CENTRAL FLORIDA TRIBUTARY TO THE GULF OF MEXICO.

PLATE LII.	(1) *Notropis metallicus.* (2) *Fundulus ocellaris.* (3) *Fundulus seminolis.* (4) *Jordanella floridæ*	302
LIII.	(1) *Zygonectes chrysotus.* (2) *Lucania goodei.* (3) *Etheostoma quiescens.* (4) *Elassoma evergladei*	302

AN INVESTIGATION OF THE COAST WATERS OF SOUTH CAROLINA WITH REFERENCE TO OYSTER-CULTURE.

PLATE LIV.	—Debidue Sound to South Island	330
LV.	—Raccoon Key to Long Island	330
LVI.	—Long Island to Kiawah Island	330
LVII.	—Kiawah Island to Otter Island	330
LVIII.	—Otter Island to Pritchard Island	330
LIX.	—Capers Island to Hilton Head Island	330
LX.	—Hilton Head Island to Jones Island	330

OBSERVATIONS ON THE HATCHING OF THE YELLOW PERCH.

PLATE LXI.	—(1) Eggs before Spawning. (2) Eggs after Spawning	334

BIOLOGY OF THE OYSTER-GROUNDS OF SOUTH CAROLINA.

Page.

PLATE LXII.—Fringing Oyster Ledge, showing living Raccoon Oysters and the Formation of Shell-banks, Stono River, east shore 362
LXIII.—Oyster Flat, showing Mud Banks and Natural Draining Trenches 362
LXIV.—Oyster Island. A dense community of Raccoon Oysters occurring in muddy, marsh-draining Streams. 362
LXV.—Tidal Zone of Oyster Distribution in South Carolina, indicated upon Piling of Wharf, Sullivan Island .. 362
LXVI.—An Oyster Flat, showing far and wide the extent of Raccoon Areas 362
LXVII.—(1) A photo-micrograph of the diatom, *Surirella gemma*. (2) Food of the South Carolina Oysters; a few of the Typical Organisms 362

THE PRESENT METHODS OF OYSTER-CULTURE IN FRANCE.

PLATE LXVIII.—(1 and 2) Flat Oyster (*Ostrea edulis*); specimen from Belon, 2½ years old. (3 and 4) Portuguese Oyster (*Ostrea angulata*); specimen from the Tagus 363
LXIX.—(1) Cancale; oyster dredging. (2) Cancale; Low Tide after the Dredging; the Sorting of the Oysters. 388
LXX.—(1) Auray; the River at Low Tide, with Mud Flats exposed, showing Collectors in Place. (2) Auray; the Camion Collectors in place; a Case of Elevage for temporary use seen in the Foreground 388
LXXI.—Trehennarvour, near Auray; the Collectors of wooden trays (*Plateaux*). (2) Arcachon; the Gabarét Collector in position 388
LXXII.—Auray; Détroquage; Workers engaged in separating Seed Oysters from a Tray collector. (2) Cancale; Guardian of Park, and case for rearing Seed Oysters 388
LXXIII.—(1) Cancale; the Barrier Oyster Park; (2) Arcachon; an Oyster Park with low Banks of Fascine and Clay 388
LXXIV.—Arcachon; Parks of the same kind as in preceding figure; a General View showing their size and arrangement. (2) Ossegor, near Bayonne; a natural tidal Lake fed and drained by a shallow, swift-running Creek 388
LXXV.—(1) Arcachon; the Oyster Boat. (2) Arcachon; an Alleyway for transport, passing between neighboring Parks 388
LXXVI.—Sables d'Olonne; View of great basin of *Élevage*. (2) View of the Claires, showing the Height, Width, and Character of the earthen banks that form their outlines 388
LXXVII.—Brenneguy; the Park for Seed-culture in a large closed basin. (2) Marennes; View of the Mouth of the large Canal which passes inland and feeds Systems of Claires on either side 388
LXXVIII.—(1) Marennes; View of the Claires for Greening the Oysters. (2) Marennes; a Basin of *Dégorgement*, concreted, drained by compartments 388

FIGURES IN TEXT:

The Bouquet and Planche collectors 370

A CONTRIBUTION TO OUR KNOWLEDGE OF THE MORPHOLOGY OF LAMELLIBRANCHIATE MOLLUSKS.

PLATE LXXIX.—FIGS. 1 to 4 436
LXXX.—FIGS. 5 to 10 436
LXXXI.—FIGS. 11 to 14 436
LXXXII.—FIGS. 15 to 23 436
LXXXIII.—FIGS. 24 to 32 436
LXXXIV.—FIGS. 33 to 38 436
LXXXV.—FIGS. 39 to 44 436
LXXXVI.—FIGS. 45 to 51 436
LXXXVII.—FIGS. 52 to 64 436
LXXXVIII.—FIGS. 65 to 70 436
LXXXIX.—FIGS. 71 to 74 436
XC.—FIGS. 75 to 76 436
XCI.—FIGS. 77 to 82 436
XCII.—FIGS. 83 to 86 436
XCIII.—FIGS. 87 to 95 436
XCIV.—FIGS. 96 to 97 436

FIGURES IN TEXT:

FIGS. 1 to 3 428

PLATE I.

ENTRANCE TO MARINE GROTTO.

1.—OBSERVATIONS ON THE AQUARIA OF THE U. S. FISH COMMISSION AT CENTRAL STATION, WASHINGTON, D. C

[Plates I to IV and two text figures.]

BY WILLIAM P. SEAL.

THE MARINE AQUARIA.

The establishment of a marine aquarium at Central Station for the purpose of demonstrating the possibility of keeping marine plants and animals at a distance from the sea, and consequently with the use of a very limited quantity of water, was entered upon at the beginning of the year 1889, and has resulted so favorably as to afford abundance of argument for an extension of the work as a means of practical observation and experiment.

The system of construction adopted is the most economical and favorable possible. The building is practically a greenhouse in style, 16½ feet wide and 64½ feet long, built against the west side of Central Station, with a small extension about 8 feet in length on the south side, sufficient to accommodate the pumping apparatus, filter, etc. This style of structure, whether simple or elaborate, is necessary to afford the light required to establish favorable conditions for plant life, and no doubt in as marked a degree for the health and happiness of animal life also.

The construction of both building and grotto will be understood by referring to the accompanying ground plan. (See plate III, at end of article, page 12.)

The central space or gallery for the observation of the aquaria is completely covered with imitation rock-work made of heavy paper applied in a soft or plastic condition and afterward painted, sanded, and frosted. No part of the aquarium tanks is allowed to show except the glass, which appears like so many holes or openings in the rocks. While all extravagance in the attempt to imitate natural rock is avoided, there is still afforded a very realistic representation of a natural grotto or cavern in which the observer appears to be beneath or surrounded by water.

The idea of constructing an aquarium in any imitation of a cavern or grotto has been very vigorously assailed by Mr. W. A. Lloyd, late superintendent of the Crystal Palace Aquarium, London, England, principally from an artistic or esthetic standpoint, the argument being in general that any attempt at ornament or idealization is unnecessary and inefficient for the object sought, and therefore wasteful and inartistic.

Not assuming to be competent to affirm or deny Mr. Lloyd's conclusions from his standpoint or to form an opinion concerning attempts of this nature in European capitals, which were altogether different from the skeleton framework and light paper shell of the Central Station Aquarium, they having been built of stone and cement at great cost, I commend the idea as here employed on the score of economy, cleanliness, and general effectiveness. To have produced equally good results with wood or metal would have cost very much more. The advantages of such an arrangement are that, while the aquaria are afforded the light necessary for their success, it is cut off from the eye of the observer, except as it reaches it softened and diminished in passing through the water. A further advantage is that the attendants can carry on their work undisturbed and without annoying or distracting the attention of the observer from the aquaria. It further prevents the introduction of food, or the interference of any kind, by visitors or those not properly authorized.

Some unavoidable use of brass piping in the beginning demonstrated beyond any further need of experiment the necessity for the entire absence of metals from the tanks, reservoirs, and circulatory apparatus, and consequently the materials now used in their construction are glass, slate, hard and soft rubber, and wood, nothing being used which is oxidizable or capable of exciting galvanic or chemical action.

The use of an awning covering the entire structure affords the necessary protection from excessive heat and sunlight in summer.

A gas engine with hard-rubber pump supplies the means of elevating the water to a sufficient height to give the pressure necessary for effective aëration.

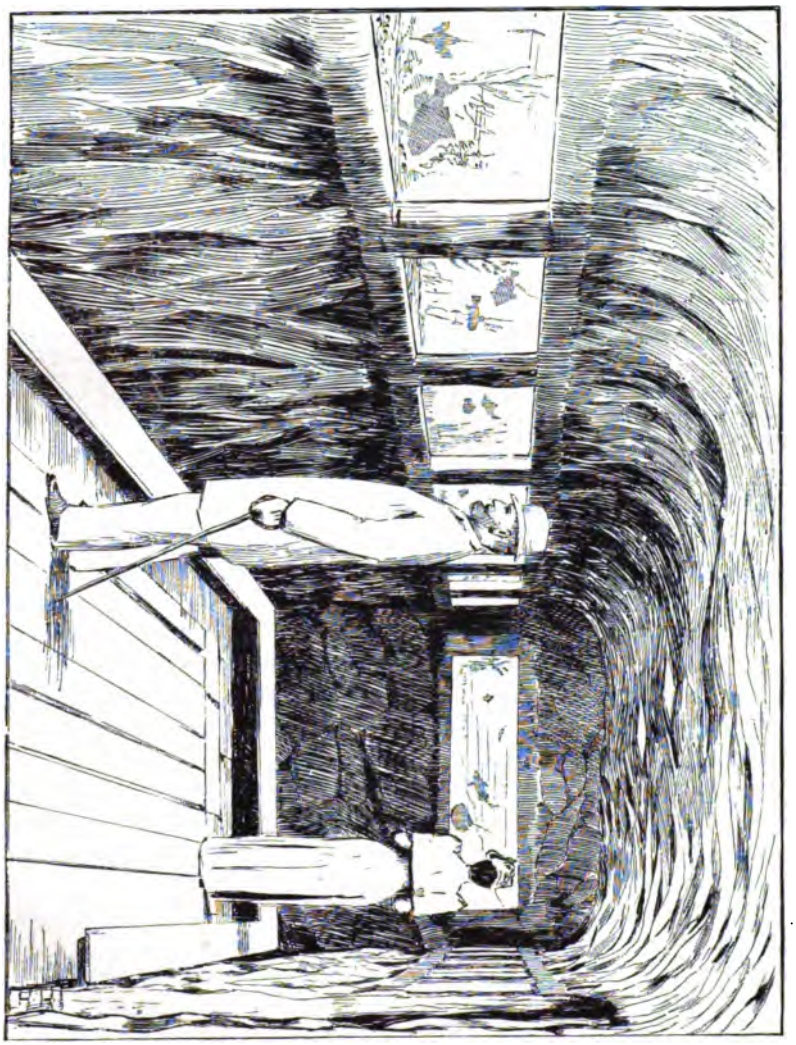
The number of aquaria in the marine grotto is twenty-four, having an aggregate capacity of about 1,800 gallons of water. The elevated tank holds something over 400 gallons. The reservoir, located in the yard of Central Station and inclosed with wood and glass, holds about 4,000 gallons of water, thus making a total of about 6,000 gallons in the circulation. The upper tank, being at an elevation of about 40 feet, gives a pressure of about 20 pounds to the water entering the aquaria.

By passing the water through very small glass nozzles (one thirty-second to one-eighth inch orifice, as required) at this pressure a small amount of water suffices, as a very large amount of air is drawn in with it and dispersed throughout the entire body of water in an aquarium in minute bubbles, thus affording efficient aëration.

In addition to this circulatory system, there is an auxiliary system of aëration, which is used in case of unavoidable suspension of the circulation, and is also valuable in special cases and in the aëration of water of other degrees of density than that in the main body of salt water.

This system, devised by Hon. Marshall McDonald, is a modification of the various air-pumps in use, which are operated by a fall of water through tubes, and is so simple and efficient as to be of very great value, and within the reach of all, for the aëration of a single aquarium kept for amusement or for the greater needs of institutions of learning. Artificial aëration, or change or circulation of water, is necessary where more than a certain proportion of aquatic animals are kept in a given amount of water. For the keeping of marine forms of life where the supply of salt water is necessarily limited and especially for the uses of biological laboratories, this device should prove of very great value.

To establish such a pump there must be first a fall of water. As but a small amount is necessary for the operation of a single pump, it may be carried up from a



INTERIOR VIEW OF MARINE GROTTO.

watercock, conveniently located, by means of small rubber tubing. The higher it can be carried, the greater will be the force created. The fall should be 8 or 10 feet at least, and 20 or more feet will make it much more efficient. The higher it is carried, however, the stronger the tubing must be. From this tube a small stream of water, cut down to a gentle flow, is allowed to drop into another tube having an enlarged mouth and of one-fourth to three-eighths inch bore, drawing in with it air, thus inducing capillarity, the air forming into globules or bubbles alternating with water spaces, as shown in fig. A 1, plate IV.

In the illustration the tube is shown as being attached directly to the cock and with a hole in the side for the induction of air. This method of attachment is probably the best, and might be made more effectual by the use of a metal supply-pipe.

Some provision is necessary for carrying off the water in case of any accidental stoppage of the pump, as when the water is prevented from passing down the tube it finds its way out of the air-hole at the top. A funnel-shaped receiver with a nipple inserted into the side, to which may be attached a piece of small rubber tubing leading to a sink or other exit, might be placed on the tube below the air-hole and would probably be as simple and effective as anything; but this can be left to individual ingenuity.

A small nozzle has been used through which to pass the water into the tube (A 1) with force, but it is probably no more efficient, while great strain is brought on the tubing attaching it, often causing it to burst, and it is also liable to become choked by small crustaceans, scale from the water-pipes, etc.

Through the tube (A 1), which is an enlarged sketch of what would be the top of the supply tube (A 2), the air and water pass into a jar, B, which has, in addition to the entrance or supply tube, two exit tubes, all passing through an air-tight cork or stopper, C. One of these tubes, D, merely passes through the stopper and is for the exit of the air, which of course remains in the upper part of the jar or above the water, while the longer one, extending to the bottom of the jar, is for the exit of the water.

A proper regulation of the height of the overflow-pipe outside the jar will regulate the flow of air into the aquarium. This regulation is necessary to equalize the pressure, as it will vary with the proportion of air and water passing into the jar, the depth of water in the aquarium, etc.

Several forms of liberators for the air passing into the aquaria have been devised. The difficulty in efficient aëration in this way has been in the tendency of the escaping globules of air to coalesce and form large bubbles. The more finely the air can be comminuted the more rapidly it will be absorbed by the water, and consequently the more perfect the aëration will be. Many kinds of dead wood, which are porous, such as grape-vine, have been found to liberate the air in very minute bubbles, and sponge properly inserted into the mouth of a glass tube bent in the shape of a hook so that the mouth will open upwards has worked well. It is probable that many other more satisfactory porous materials may be found.

The original supply of salt water was brought from Chesapeake Bay, and from time to time when the Commission's steamer, the *Fish Hawk*, returns to Washington an additional supply is obtained. This, however, does not supply all loss from various causes and artificial sea water has sometimes been used. This has been made by using a salt produced by evaporating sea water.

The usual method of preparing artificial sea-water for the aquarium is by use of one of the many formulas provided for the purpose. In the present case Turk's Island salt is used. The writer has used this salt for preparing salt water for small still-water aquaria with perfect success, and it has proven satisfactory in the present case. There was in the beginning some principle, apparently mildly acrid or astringent, affecting more or less unfavorably all of the lower forms of life, while it had but little noticeable effect on the fishes. Fishes having a slimy mucous coating, such as the toad-fish, appeared to lose it and the skin became shriveled in appearance, but their general health seemed unaffected.

It appeared probable that, as there is a considerable precipitate of lime from this salt in solution, some of it may have remained in suspension for a long time owing to the activity of the circulation. It was noticed at least that in the same water which is quiet and has stood for some time the low forms of life kept in much better condition, but without some form of aëration the amount of life so kept must be very limited. The result was all the more puzzling because of the fact that some fish usually very difficult to keep lived remarkably well. Among these was the gizzard shad, transferred from fresh water. It was finally found to be necessary to exercise more care in introducing the water into the reservoir so as to avoid stirring up the precipitate of lime formed at the bottom of the vessel in which the solution was made. After this precaution was taken the disturbing effect disappeared.

It appears, from a paper by R. S. Hoffmann in the Bulletin of the U. S. Fish Commission for 1884, that the Berlin, Hamburg, and Vienna aquaria encountered in the beginning numerous difficulties in the preparation of artificial sea-water, threatening failure for a considerable period.

The director of the "Zoophyte Aquaria" in the Zoological Garden in Regent's Park, London, declared some years ago that "artificial sea water, even if a chemical analysis can not discover the least difference between it and natural sea water, is never beneficial to animals and plants;" but this has been disproved by the success of the aquaria at Berlin, Hamburg, and Vienna. In 1884 the artificially made sea water of the Hamburg aquarium had not been changed for 15 years, and was then perfectly transparent and odorless, and in every way satisfactory.

A minute green organism which appeared in the water of the Washington aquarium during a long and unavoidable suspension of the circulation during the summer of 1889 in such numbers as to render the water opaque was finally eradicated by causing the water to pass through a filter composed of sand and gravel of graduated sizes on its way to the reservoir.

One of the interesting evidences of the advantages of the greenhouse system employed, affording abundance of light, is the beginning of the development of algæ directly from spores on the slate work of the aquaria and on the stones placed therein. There is apparent evidence that in time there will be a dense growth of algæ adapted to the changed conditions, just as on sea-walls, piles, etc. This is a matter of slow development in nature, so that some time will elapse, probably, before there is a very complete realization of this expectation.

The necessity for light is most effectually illustrated by the fact that this plant development is greatest in the aquaria at the southern end of the grotto, diminishing gradually towards the northern end, which does not receive so much sunlight.

The plant and animal life has been supplied by seining expeditions to Chesapeake Bay, and by several lots of specimens brought by the Commission's steamer *Fish Hawk* on her returns from work of investigation.

During the springs of 1889 and 1890 a number of the eggs of the horse-shoe crab (*Limulus*) were received by mail from Delaware Bay by Dr. Hugh M. Smith, of the Fisheries Division of the Commission. They were sent by Mr. E. S. Howell, of Dias Creek, New Jersey, packed in wet sand in small tin boxes. They hatched and developed until about three-eighths or one-half inch long, when they began to die off gradually, probably from lack of proper food. The adults in the aquarium feed on beef, clam, and fish.

A number of nests of the 2-spined stickleback (*Gasterosteus aculeatus*) were built, affording an opportunity for observation of the breeding habits of that species. The nest is composed of a mass of vegetable fiber and shreds of algæ, living and dead, deposited on the bottom of the aquarium or on the flat upper surface of a piece of rock. It is not so elaborate as that of the 4-spined species, but is bound together in the same manner by means of a thread spun by special secretive glands, as described by Prof. John A. Ryder, in the Bulletin of the Commission for 1881, in the case of the 4-spined species. The young are protected by the male after hatching by driving away other fish, and by giving them an education in self-protection. He will dart at the young as if about to devour them, causing them to take refuge among the plants and stones, to again emerge as he darts off in pursuit of fish venturing near. With a vigilance that is incessant and untiring they are thus guarded and driven under cover until finally they flee and hide at the passing of a shadow over the water.

During the spring and summer of 1889 four species of Cyprinodonts spawned in the aquaria and their spawning habits and sexual coloration were noted.

The readiness with which these small species spawn in captivity justifies the belief that when adequate conditions are afforded for our larger fishes similar results will be attained with them. Such a consummation would undoubtedly lead to the most practical advance possible in our knowledge of the habits of our fishes.

It was noticed, on transferring some white perch (*Roccus americanus*) suddenly from fresh to salt water, that they were so buoyant as to be unable to swim beneath the surface, the dorsal fin and part of the back being out of the water, and that it was only after some days that they acquired the proper specific gravity and could swim about normally. This probably explains the necessity for a gradual change from water of one density to another, they not appearing to suffer from the effects of the salinity.

In a similar experiment with some eels they were able to keep near the bottom, but had a tendency to stand on their heads.

A very interesting experiment has been made in confining fishes infected with fungus (generally as a result of injuries received in transportation) and such as are infested with parasites, in brackish water for a time. It is well known by all who handle live fish that they are very easily injured. The scales may be detached, the fins torn and abraded, the lips bruised and torn from knocking against the sides of the can or box, and the whole mucous coating and skin more or less scratched and bruised. Many of these injuries do not show for some days, and it is possible that where fish are speedily restored to natural conditions at the end of their journey they may find in the mud or in some other source a healing specific which will effect a cure. In the aquarium, however, they are soon attacked by fungus (*Saprolegnia*), and in their generally depressed condition, refusing food although undoubtedly slowly starving,

they soon succumb. The usual method of treatment in such cases is to dip them frequently into salt water. While many other solutions, such as carbolic acid, washing soda, etc., are frequently used, it is quite probable that the salt water is as efficacious as any of them and much less liable to do harm. The labor involved, however, in treating a number of fish in this manner is very great, and the splashing and slopping occasioned by large fish is a further objection.

It is also a question as to whether the injuries inflicted upon fish by the frequent handling of them, especially in the common knot-woven net, are not as great as the benefits received from the treatment. However that may be, the experiment herein described seems to open up a very simple and efficacious treatment of fishes so injured. The water in the aquarium was brought to a density of 1.006. The fish experimented upon were large-mouthed black bass, white bass, red-eye or rock bass, crappie, yellow perch, white perch, eel, sunfish, carp, goldfish, and catfish. The under lips of the black bass were badly torn and completely covered with fungus. There is no question in the minds of any who saw them and understood their condition that they would have speedily died in a fresh-water aquarium. After a month's sojourn in the brackish water they were fully restored, with a new skin grown over what were ragged festering sores. While in the brackish water they commenced to feed upon small minnows given them, whereas in the fresh water they would not feed at all. In every repetition of this experiment the same favorable results were obtained.

The crappie is a timid and very delicate fish, easily injured by transportation. It is soon attacked by fungus. In every instance it has been speedily restored by the brackish-water treatment. All the other species mentioned were quickly cured of injuries or freed from fungus in the same way.

The goldfish and carp are frequently infested by a minute infusorian parasite, the identity of which is not yet certain, and the catfish, sunfish, white perch, trout, and others, are in winter infested by a parasite, *Chromatophagus parasiticus*, and all of these have yielded to the brackish-water treatment.

It seems assured also, from the experiments made, that any of our fresh-water fishes will live for an indefinite time in salt water about one-fourth the density of sea water; whether an artificial solution will answer as well as the sea water itself is yet to be determined. There is an interesting field for experiment and observation thus opened up in this direction. It has been found also that, to some extent at least, beneficial effects have followed the temporary transfer to brackish water of species supposed to live wholly in sea water.

All of the salmon and trout may be transferred suddenly from fresh water to water having a density of 1.010 without inconvenience to them, and the water can then be brought up to the full strength in the course of two or three days.

It should be stated that the density of the main body of water is kept at 1.020, as that has been found to be sufficiently saline for any species whatever, and also to be more generally favorable to all species.

The aquaria have proven to be very popular, and the expressions of wonder and delight are universal; and many zoölogists, and biologists in particular, are gratified that at last there is a possibility of the development of conditions affording the means for the study of marine as well as fresh-water forms in a living condition where access may be readily had to works of reference.

Of course it is not to be assumed that the ultimate measure of success will be sud-

denly attained. Much is yet to be learned regarding the requirements of all forms of life under artificial conditions. The temperature at one season is unfavorable for some species, and at another season for other species. There may be a necessity for a change of density of water at certain seasons for some species as well as the nearly uniform temperature which they find in nature by migration, and these are impossible to provide for under existing conditions. All of these and many other influences are matters well worthy of investigation in the general interests of science, to say nothing of the advance of knowledge necessary in the holding and handling of many of our fishes for the more practical purposes of propagation.

The realization of these objects must be accomplished through the medium of years of investigation and patient observation and experiment, based upon a knowledge of past progress in this direction, and a comprehensive idea of and faith in the possibilities of fish-cultural development. All the experiences of the past, successes and failures, point to the necessity of approximating natural conditions more closely in the keeping of living things in captivity.

Some fishes are less easily kept or transported than others, principally, it is believed, from mental effects alone. Many are physically much more tender and more easily injured than others. The young of a species will endure the conditions of captivity, while the adult will refuse food and pine and die.

In the future development of aquaria, and in all attempts to hold fish or other animals for purposes of study or propagation, all of these influences of environment must be considered. To ignore them is to limit the chances of success, or to invite absolute failure. All the advances made will be upon the lines of imitating nature more closely, so as to render animals measurably happy and contented by affording such conditions as will promote a normal and healthy physical condition and development.

THE FRESH-WATER AQUARIA.

There are twenty-five tanks devoted to fresh-water fishes; they vary in capacity from 10 gallons to almost 300 gallons. The conditions afforded are, as a rule, unfavorable, owing to the impossibility at present of having the proper amount of light for healthy plant growth, upon which depends the proper condition of the water as well as the health and happiness of the fishes. The prevalence of fungus is very great, leading to the conclusion that the conditions for its development are very favorable. There are animal parasites, also, which at times become veritable plagues, but which, under natural surroundings, do not appear to exert any injurious influence on fishes. Some means of controlling the temperature of the water in winter would be very desirable, as, when it approaches the freezing point, the fish generally refuse food, and not being afforded the opportunity for the semi-hibernation possible to them in nature, they soon succumb. These matters are mentioned not as difficulties which can not be overcome, but rather as the unavoidable results of an enforced economy.

One very persistent and troublesome form of parasite is described in the Report of the Commission for 1884, by Dr. S. Kerbert, as *Chromatophagus parasiticus*. This parasite is an infusorian which encysts itself in the skin of fishes and but few are exempt from its ravages. So completely will a fish become infested with them that it would be difficult to find a spot as big as a pin's head free from them. Many experiments have been made to find means of destroying it, but, until the efficacy of confinement in

brackish water was noticed, it was impossible to restrict its ravages. When thus infested the fish will refuse food and by scratching themselves violently on the sand or stones will soon produce an inflamed condition of the skin and a rapid growth of fungus, to which influences they soon yield and die.

The necessity for a supply of brackish water in circulation, in addition to the salt and fresh water system, is thus demonstrated to be of the greatest importance, from a practical and economical standpoint.

The prevailing muddy character of Potomac River water renders it necessary to employ some means of filtration. The system now in use (the Loomis), although probably as good as any, if not the best of the same character in use, is open to serious objections from several points of view. It requires frequent cleaning to render constant good service. The use of alum as a coagulator involves the necessity of very great watchfulness on the part of those required to attend to the operation of the filter. The amount of alum dissolved, or necessary to take up the matter in suspension in the water, appears to vary somewhat with temperature. The muddying and clearing of the water must be closely watched and the alum feed regulated to correspond. A very slight amount of alum will affect fish, and accidents will occur with the most watchful under such circumstances.

There is a question also as to whether, although apparently having no direct injurious action on the fish, something in the character of the water after filtration by the alum process may not be, in part at least, the cause of the difficulties encountered from fungus. It is stated in the Report of Walpole and Huxley, inspectors of fisheries of England and Wales, for 1881 (See Bull. U. S. Fish Com. 1881), that—

> It is known with respect to many of the common molds such as *Penicillium* and *Mucor*, which are habitually saprophytes (that is to say, live on decaying organic matter as *Saprolegnia* does), that they flourish in certain artificial solutions containing salts of ammonia. It is quite possible, though whether the fact is so will have to be experimentally determined, that *Saprolegnia* is capable of living under the same conditions. Fungi are also extremely sensitive to slight differences in the acidity or alkalinity of water, so that even apparently insignificant changes in that respect may come into play as secondary conditions of salmon disease. * * * A factory for making a spirit from turnips was established near Schweidnitz, in Silesia, and the refuse was poured into an affluent of the river Westnitz, which runs by Schweidnitz. The result was such a prodigious growth of *Leptomitus* that the fungus covered some 10,000 square feet of the bottom of the stream with a thick white layer compared to sheep's fleeces, choked up the pipes, and rendered the water of the town undrinkable.

The writer has noticed similar developments of fungus, possibly the same, in streams into which the refuse of creameries was allowed to drain. On the other hand, the presence of fungus in such quantities in the fresh-water tanks at Central Station may be due, to a great extent, to the lack of light afforded them and the consequent absence of growing aquatic plants, as in those tanks where there is an abundance of light and a healthy plant growth it gives no trouble, in fact is practically unknown.

The attempts to establish an exhibit of live fishes at the New Orleans Exhibition failed because of the use of alum in filtration. At the Ohio Valley Exposition, at Cincinnati, Ohio, in 1888, very great difficulties were encountered in establishing an exhibit of aquaria, owing to the muddy character of Ohio River water and the high pressure of the water supply there. Some accidents occurring threatened for a time a failure of the live-fish exhibit. The difficulties were finally overcome, but, together with the other experiences and observations herein recorded, point to the desirability

denly attained. Much is yet to be learned regarding the requirements of all forms of life under artificial conditions. The temperature at one season is unfavorable for some species, and at another season for other species. There may be a necessity for a change of density of water at certain seasons for some species as well as the nearly uniform temperature which they find in nature by migration, and these are impossible to provide for under existing conditions. All of these and many other influences are matters well worthy of investigation in the general interests of science, to say nothing of the advance of knowledge necessary in the holding and handling of many of our fishes for the more practical purposes of propagation.

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would remain ensconced in the shelter thus made, but no spawning was observed in such situations, the preference appearing to be for the denser masses of plants high up or among the pebbles on the bottom.

The spawning of the tessellated darter was wholly as described on the sheltered sides of stones, but their presence in the same tank may have interfered with the natural habits of the others.

The quick, jerky, energetic, climbing and darting movements of both species are much like those of the nut-hatches among birds.

BREEDING HABITS OF FRESH-WATER MUSSELS.

Three species of *Unionidæ* were under observation during the spring of 1890, which showed the manner of development and escape of the young. The accompanying sketches of two species are traced from water-color pictures by Mr. S. F. Denton.

The specimens were not positively identified by the conchologist who observed them. It will be seen that while the shells are outwardly very much alike the peculiar development of the mantle is very different in each and would afford a ready means of identification in the breeding-season.

The difference in color is also very great. In the one with the small tentacles the color of the mantle is white, tipped with pale yellow, with the gills, which also inclose the eggs and appear as the lobed central mass, a pale slate color. In the other the mantle is salmon color from pale to quite deep tints, while the egg-sack is purple.

In each of them the peculiar processes or tentacles were kept constantly in motion, in the one waving like cilia, while in the other they were constantly clasped and unclasped, crossing as a pair of arms.

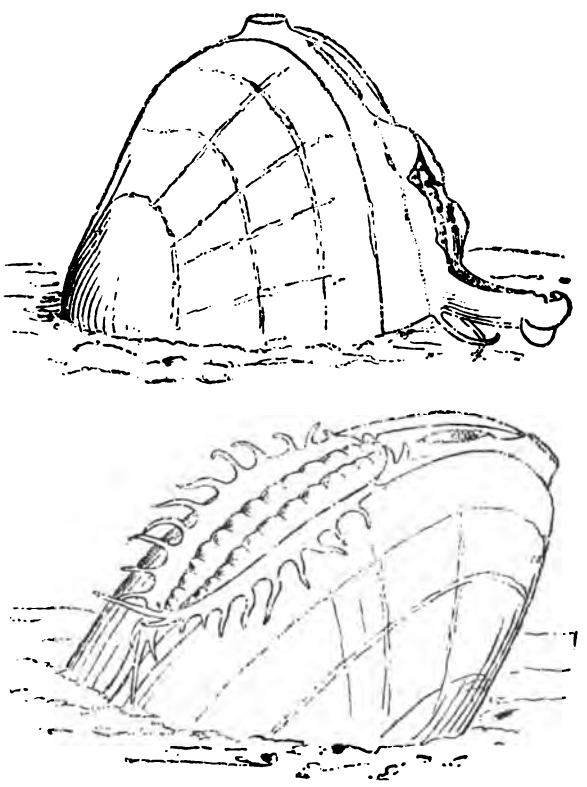

FIG. 2. Fresh water Mussel throwing off the young.

No sketch was made of the third species. There was no such extensive development, there being simply two rows of short tentacles of equal length, which were kept in constant wave-like motion after the manner of cilia.

The first two specimens were from ponds in which there is no current, and this probably accounts for the necessity of an extensive development of tentacles for the purpose of inducing circulation and providing food and fresh water. The third was taken

The markings on the fins of the males become at this period very bright and distinct, and add more to its ornamental appearance than the brightest coloration does to other species. The colors assumed at this period are a mingling of delicate and indefinable shades of blue and green with bronze and iridescent reflections, which, with the striking effect produced by the markings, make it perhaps as beautiful as any of the family, if not so gorgeously colored.

The "rainbow darter," also called blue darter, soldier fish, etc., is probably not found east of the Allegheny Mountains. It is one of the most highly colored species of the family *Percidæ*. The prominent colors are red, yellow, orange, blue, and green, arranged in conspicuous patches, or regular patterns of the most striking character. The specimens in the aquaria are from the vicinity of Cincinnati, Ohio, and Neosho, Missouri, and correspond perfectly in color and markings.

The following probably inadequate description of the markings may give some idea of the gorgeous colors of the fish: Lower half of spinous dorsal deep brick-red with a line of lemon-color arranged in a series of arches on the membrane just above the back; a lemon-color line, composed of a series of arches also, at the upper margin of the dark brick-red, arranged in reverse order to the lower lemon line, that is, with the concavity of the arches turned upward; the upper half of the fin of a very deep indigo-blue. Soft dorsal, an artistically arranged pattern of green, blue, yellow, and light brick-red, difficult to describe except by diagram. Ventral and anal fins with broad band of pale-blue (becoming more intense at times of greatest excitement) at base and tips, with a broad central band of deepest indigo-blue; pectoral fins transparent, yellow at base; caudal transparent, bordered with dusky and pale blue; a blue blotch across the nape; breast with small orange spot; a lemon-yellow dash around the throat.

This species is more addicted to perching on aquatic plants near the top of the water; this habit, with its darting movements (which are analogous to the flight of birds), not having a swimming bladder, make it very bird-like in appearance.

At the spawning period a spot would at times be selected, apparently, among the plants as a place of deposit for the eggs, and, although in their active sexual demonstrations they would travel to every part of the tank, they would invariably return and perch in the same place. As with the tessellated darter, there was undoubtedly a mating, although usually two or three other males would hover very near and frequently make rushes to join the female, in which they were invariably defeated and driven away by the chosen male. At times the spawning would take place among the pebbles on the bottom of the tank, the female dragging herself along in a quivering manner, the male pressing closely alongside, and other males following closely in the rear, evidently bent on assisting in the fertilization of the eggs. All the fish not actually engaged in the spawning were evidently in a state of great excitement, and followed after, eating the eggs as fast as they were deposited. As the tessellated darters are much the larger, the eggs could hardly have been protected from them, although many smaller fish, notably the 4-spined stickleback, under like circumstances, would attack anything regardless of size.

It is probable that in a wholly natural condition the eggs are deposited on the under or protected sides of stones where they would be more easily guarded. In the limited space of an ordinary aquarium tank, well stocked for exhibition, there would hardly be a sufficiency of desirable spawning-places for all. In some cases the females would remove the sand from beneath a part of small stones by means of the fins and

would remain ensconced in the shelter thus made, but no spawning was observed in such situations, the preference appearing to be for the denser masses of plants high up or among the pebbles on the bottom.

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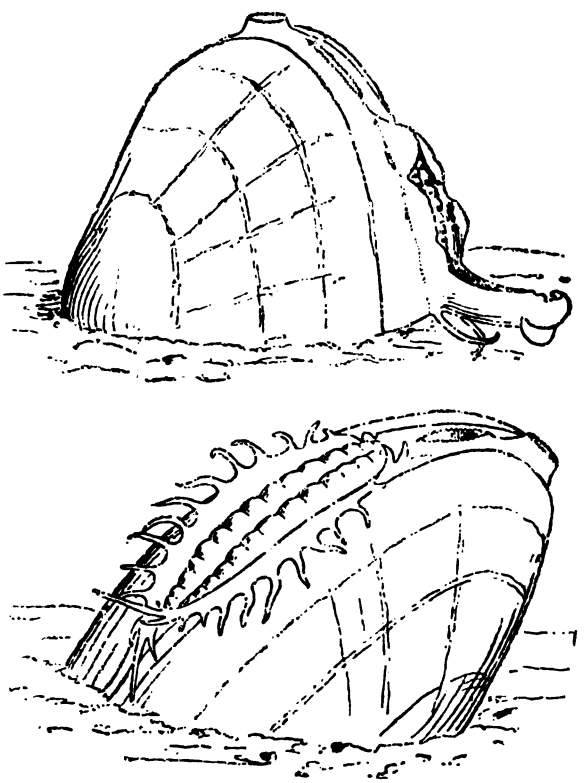

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from a rapid stream flowing into the Potomac and, having abundance of circulation through natural currents, did not need so elaborate a development of tentacles.

The authorities say of the generative habit that the eggs are fertilized in the fall of the year and are carried by the female through the winter, meanwhile undergoing development to the swimming stage. About March they make their escape and enter into the swimming stage, during which they are armed with hooks, by means of which they fasten themselves to aquatic animals, where they undergo further development, finally dropping off and sinking to the bottom as the fully developed mussel, but still very minute.

A PECULIAR HABIT OF A HOLOTHURIAN.

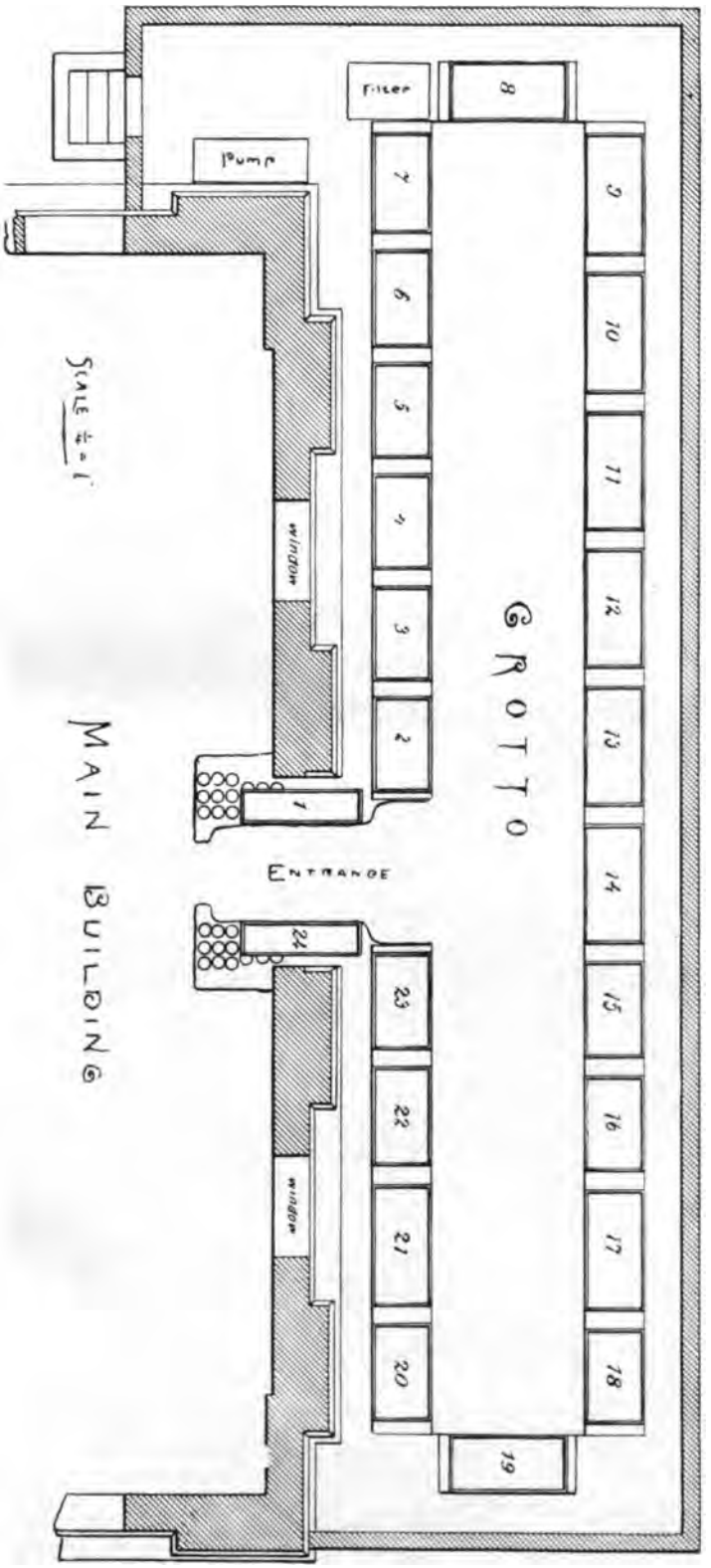
A holothurian, or so-called sea-cucumber, in one of the tanks was observed to eviscerate itself, as is their known habit. It immediately put forth a new set of branchiæ, very delicate and transparent, but somewhat smaller than usual. This would indicate that the new organs are developed before the old are thrown away. The branchiæ of this species of holothurian are ordinarily dark gray in color. The new ones were white, translucent, and beautifully lobed and branched, not having the usual fringed appearance given to them by the development of numbers of still more minute lobes. They were evidently only partly developed and looked like some of the small and delicate red algæ with all the coloring matter bleached out.

SPAWNING OF OVO-VIVIPAROUS FISH.

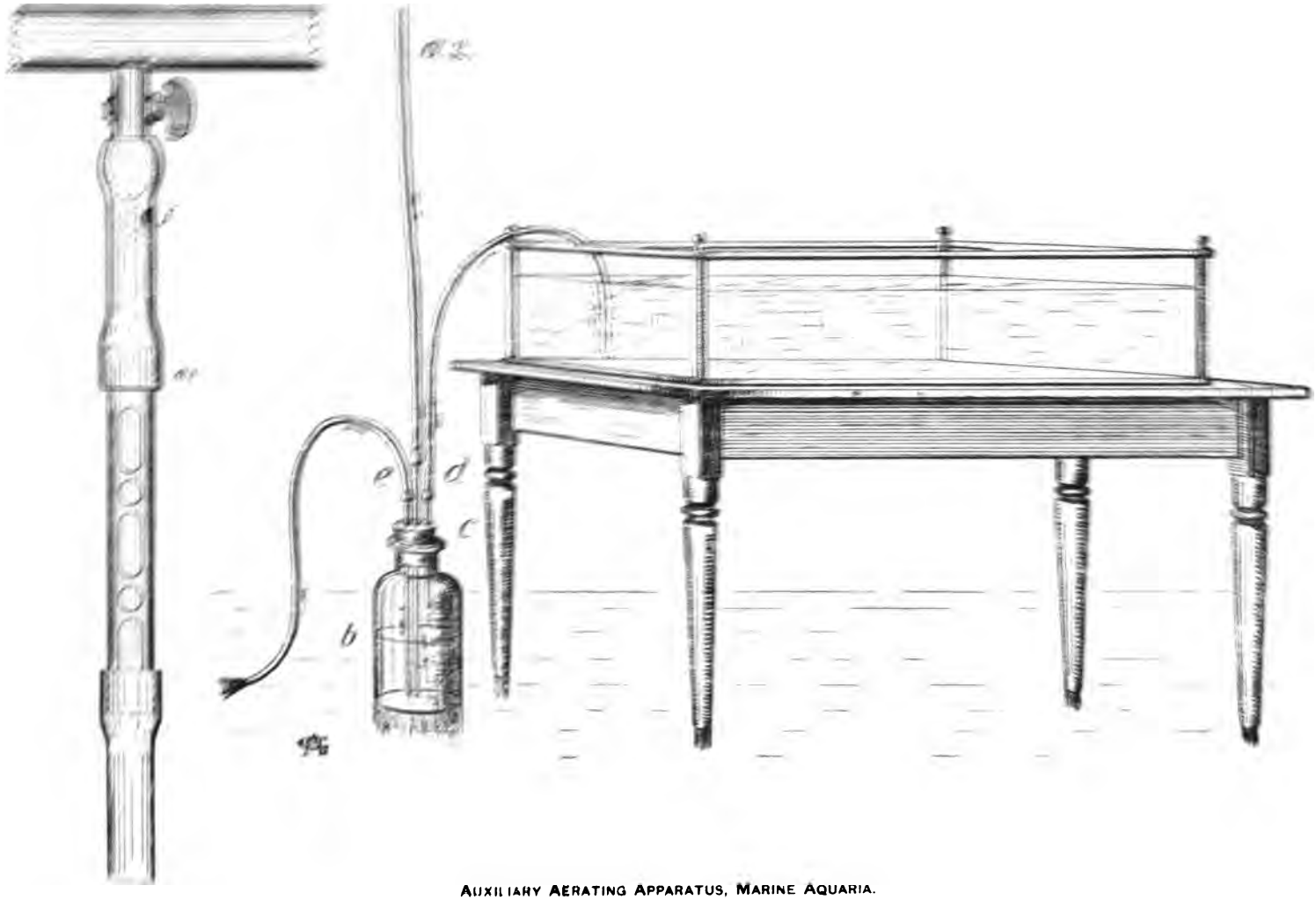
The top-minnows (*Gambusia patruelis*) have frequently brought forth their young in an aquarium and they have been reared to maturity, but all attempts to observe the method of fertilization or the extrusion of the young have failed.

In conclusion it may be said that many minor observations of more or less value to science or practical fish-culture have been made.

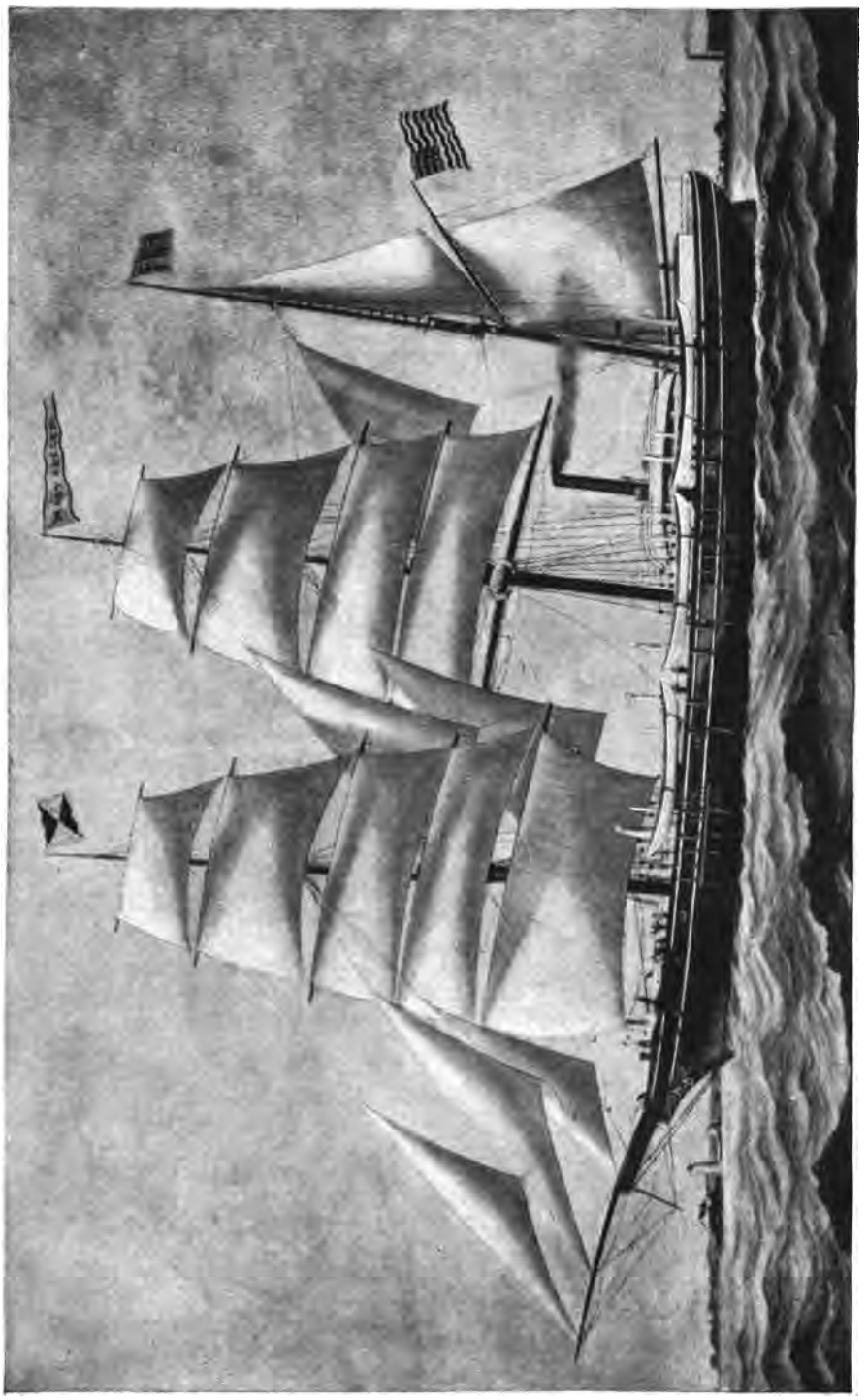
Altogether the results herein noted, while not extremely important, point to possibilities of great practical value when adequate facilities are afforded.



GROUND PLAN OF MARINE ANNEX.



AUXILIARY AERATING APPARATUS, MARINE AQUARIA.



STEAM WHALING BARK MARY AND HELEN, OF NEW BEDFORD.

2.—THE FISHING VESSELS AND BOATS OF THE PACIFIC COAST.*

BY J. W. COLLINS.

[With 13 plates and 4 text cuts.]

Many of the vessels employed in the Pacific Coast fisheries are not typical fishing craft, or, at least, have not been developed as an outcome of the fisheries and specially constructed for the purpose. Many of those built for the trade came from New England, and under this head would be included whaling ships as well as schooners employed in the cod and halibut fisheries.

I.—THE WHALE FLEET.

1. *General remarks.*—In recent years San Francisco has become the principal winter rendezvous for fleets engaged in the whale fishery in the Pacific and Arctic Oceans. The Arctic and Okhotsk Sea fisheries are now of special importance, and most of the vessels employed in them in summer return to San Francisco in the fall, land their catch, and remain there until they refit for another northern voyage or, as is commonly the case, start on a preliminary cruise in the Pacific.

San Francisco has now become largely interested in the whale fishery, and, perhaps as a natural result, many of the vessels sailing from there are those purchased from whaling ports in New England. Thus we find that several of the steamers and barks which constitute the larger part of the fleet are typical New England whalers. A number of whaling vessels have been built on the Pacific Coast. These are generally modern in type; several of them are first-class auxiliary steamers and resemble the latest additions to the New England whaling fleet. But, judging from a series of photographs of San Francisco whalers, now in the possession of the U. S. Fish Commission, it would seem that a considerable number of steamers and perhaps a smaller number of sailing vessels, particularly schooners, have been taken from other trades and put into this business without regard to their special adaptability as originally constructed. Ordinary coasting steamers and other vessels have been fitted up and strengthened, to make them, as far as practicable, suitable to encounter the perils and peculiar conditions incident to the whale fishery among the ice-floes of the northern seas. The vessels that go to the Arctic have their bows heavily sheathed with hard wood and iron, while they are otherwise made stronger so that they can successfully endure the strain and pounding which are inevitable when making passages through ice-floes.

For Arctic fishing auxiliary steamers are by far the most serviceable and least

* These notes were primarily intended for publication as a part of a report on the fisheries of the Pacific Coast of the United States, but circumstances have made it expedient to print them separately.

liable to disaster, but the additional cost of building and running has prevented a rapid increase of this class of vessels.

In recent years schooners ranging from 80 to 150 tons have come into favor for ice fishing. These vessels are lighter and handier than sailing barks of 300 tons or more and can work to greater advantage through leads in the ice. Besides, they are much less liable to be crushed, since their light draft, which generally does not exceed 10 to 11 feet, enables them to get close to the "ground ice" or "shore ice," or perhaps to work into coves or crevices to avoid danger from floe-ice that may be driven in against the coast. The barks usually draw about 14 feet, and, with rare exceptions, will take bottom outside of the shore ice. They are thus exposed to the danger of being crushed or driven in so hard on the bottom that it is difficult or impossible to get them afloat again. The small size of the schooners is no special disadvantage to them so far as capacity for their catch is concerned. As a rule they save only the whalebone or the hides and ivory of walrus, and the smallest of them usually have ample room for these products.

The following notes relative to steam whaling vessels are extracted from an unpublished report on fishing craft of the United States that was prepared by the writer.

2. *Introduction of steamers in the whale fishery.*—With the single exception of the *Pioneer*, a former Government transport, which was transformed into a steam-whaler in 1865, the whaling fleet of the United States previous to 1879 was composed wholly of sailing vessels.*

The many perils encountered in the whale fishery of the Arctic seas, where the vessels are constantly liable to be nipped by the heavy ice; the necessity for making rapid passages from one whaling ground to another; the demand for the prompt transportation to market of the products of the fishery, combined with the influence which no doubt was exerted by the example of the English, Scotch, and Newfoundlanders (who as early as 1857 to 1863 had employed steamers in the seal and Arctic whale fisheries),† led to the introduction of steam vessels from the United States for the prosecution of the North Pacific and Arctic whale fishery.

*"The first steam whaler from the United States," writes Mr. J. T. Brown, "was the bark *Pioneer*, 212 tons. She was built at Charlestown, Mass., as a Government transport, and rebuilt in 1865 for the whale fishery. The projectors of this enterprise were Messrs. Williams & Havens, of New London, Conn., whose names are prominently connected with the Grinnell expeditions. The *Pioneer* sailed from her home port April 28, 1866, for the Davis Strait fishery, and returned November 14, 1866, with 340 barrels of whale oil and 5,300 pounds of bone. During her second season, in July, 1867, she was crushed in the ice and abandoned. The bark *Jara* sailed from New Bedford, October 2, 1872, with a donkey engine, which was used as a power for hoisting purposes."

†"In the year 1863," writes the Rev. M. Harvey, of St. Johns, Newfoundland, "the great innovator, steam, entered the field, and the first steamer took part in this [the seal] fishery. The value of steam in connection with Arctic explorations had previously been demonstrated, and its introduction has revolutionized the sealing industry. It was soon found that steamers strongly built and armed for encountering ice possessed an immense superiority over the old sailing vessels. They could cleave their way through ice in which the sailing vessel would be powerless; could hold on to a 'seal patch' when the other would be blown off; and, carrying larger crews, could bring in immense loads of pelts when the seals were met with in abundance. In consequence, the number of steamers rapidly increased and the number of sailing vessels still more rapidly diminished. In 1866 there were 177 sailing vessels and 5 steamers; in 1873 there were 18 steamers; in 1882, 25 steamers. Since that date the number of steamers has lessened, and is now [1885] about 20. * * During the last few years 6 of the Dundee steamers formerly engaged in the Greenland seal fishery have come out here each season and, after shipping Newfoundland crews, have taken part successfully in this fishery. When it closes, they leave for the whale fishery in Davis Straits, and return to Dundee in October."

3. *The first steam-whaler.*—A limited number of steamers have been built in the United States in recent years, especially for the whale fishery. The pioneer of this fleet was the bark *Mary and Helen*, which was launched at Bath, Maine, July 17, 1879.* This vessel was bark-rigged, and provided with a full sail plan, besides which she had auxiliary steam-power and a screw-propeller. She was able to steam 6 to 8 knots an hour. The boiler and engine occupied one-third of the space below deck. She was also provided with a steam-windlass, which was operated by a separate engine, and used both for weighing anchor and for hoisting in blubber. The *Mary and Helen* was 420 tons register, her dimensions being as follows: 130 feet long on deck; 30 feet 3 inches beam; and 16 feet 8 inches deep in the hold. In her full suit of sails she had 2,850 yards of canvas. Her hull was made a trifle fuller than common, in order that she might support the increased weight of her engine and the necessary coal carried in the bunkers. She was built of oak, yellow pine, and hackmatack; she cost, when ready for sea, $65,000.

Brown makes the following interesting reference to the *Mary and Helen:*

She sailed from her home port September 12, 1879, and was sent into the ice in 1880, under the command of Capt. Leander C. Owen. After a successful cruise she was sold to the United States Government for $100,000, and under the name of *Rodgers* proceeded in search of the missing research steamer *Jeannette* and the whalers *Mount Wollaston* and *Vigilant*. She went into winter quarters at St. Lawrence Bay, Siberia, in 1881. On November 30 of that year a fire broke out in her fore-hold and she was abandoned. Her officers and crew were rescued by Captain Owen, her former commander, then master of the steam-whaler *North Star*. The *North Star*, in a remarkable succession of events, was afterwards, during the same season, crushed by ice while cruising for whales, at an almost total loss to her owners. Immediately after the sale of the *Mary and Helen* to the Government, orders were given to build a twin ship, and *Mary and Helen* No. 2 is now afloat in the whaling service. She is a counterpart of her predecessor.

4. *Other steam-whalers.*—The *Mary and Helen* engaged in the whale fishery of the northern Pacific, Bering Sea, and Arctic Ocean, and met with such success that her first season's catch paid for the ship and left a balance of $40,000 to be divided among the owners. She did not go on a second cruise, for, as has been stated, when she was ready to sail she was sold to the Government. Her success resulted in the building of other vessels of a similar type for New Bedford and San Francisco.

In June, 1880, the steam-bark *Belvidere*, the second of her class, was launched at Bath for the same owners who had the *Mary and Helen* built. She was 140 feet 6 inches long on deck, 31 feet 3 inches beam, and 17 feet deep in the hold, registering 440 tons, and was furnished with a condensing engine, cylinder 22 inches, with 28 inches stroke, and a boiler 12½ feet long and 7 feet diameter, carrying 60 pounds of steam. The second *Mary and Helen* is 151 feet long, 31 feet wide, and 17 feet deep, registering 508 tons. She was built of white oak, pitch pine, and hackmatack, had four sets of heavy pointers in the bow, braced across the vessel with heavy timbers to strengthen her against the shock of ice-floes; she carried the usual small propeller engine, and also two donkey engines in the forward house for handling the anchors and general hoisting.

When the *Thrasher* was built she was considered the most complete in her equipment. She had patent try-works and iron oil tanks in the lower hold. Her engines are single, direct-acting, with independent condenser and pumps. The cylinders are

* "The most prominent vessel of this type," remarks Brown, "both so far as the initial step in the North Pacific is concerned as well as in a historical point of view, was the late *Rodgers*, formerly the *Mary and Helen*, which was lost in the search for the *Jeannette* in 1881." (See Plate v.)

22 inches by 36 inches. This type of engine is, in the opinion of competent authority, better adapted for whaling purposes than the compound engine, and more economical.

The model and rig of these barks do not differ very materially from those of an ordinary merchantman, but they have been built a little bulkier than the average whale-ship, for reasons already stated. They were, of course, provided with the necessary davits for hoisting boats, and the try-works which are characteristic of all vessels engaged in the whale fishery.

The following particulars respecting the dimensions and the construction of modern steam-whalers were supplied by Messrs. Goss, Sawyer & Packard, Bath, Maine, who built them:

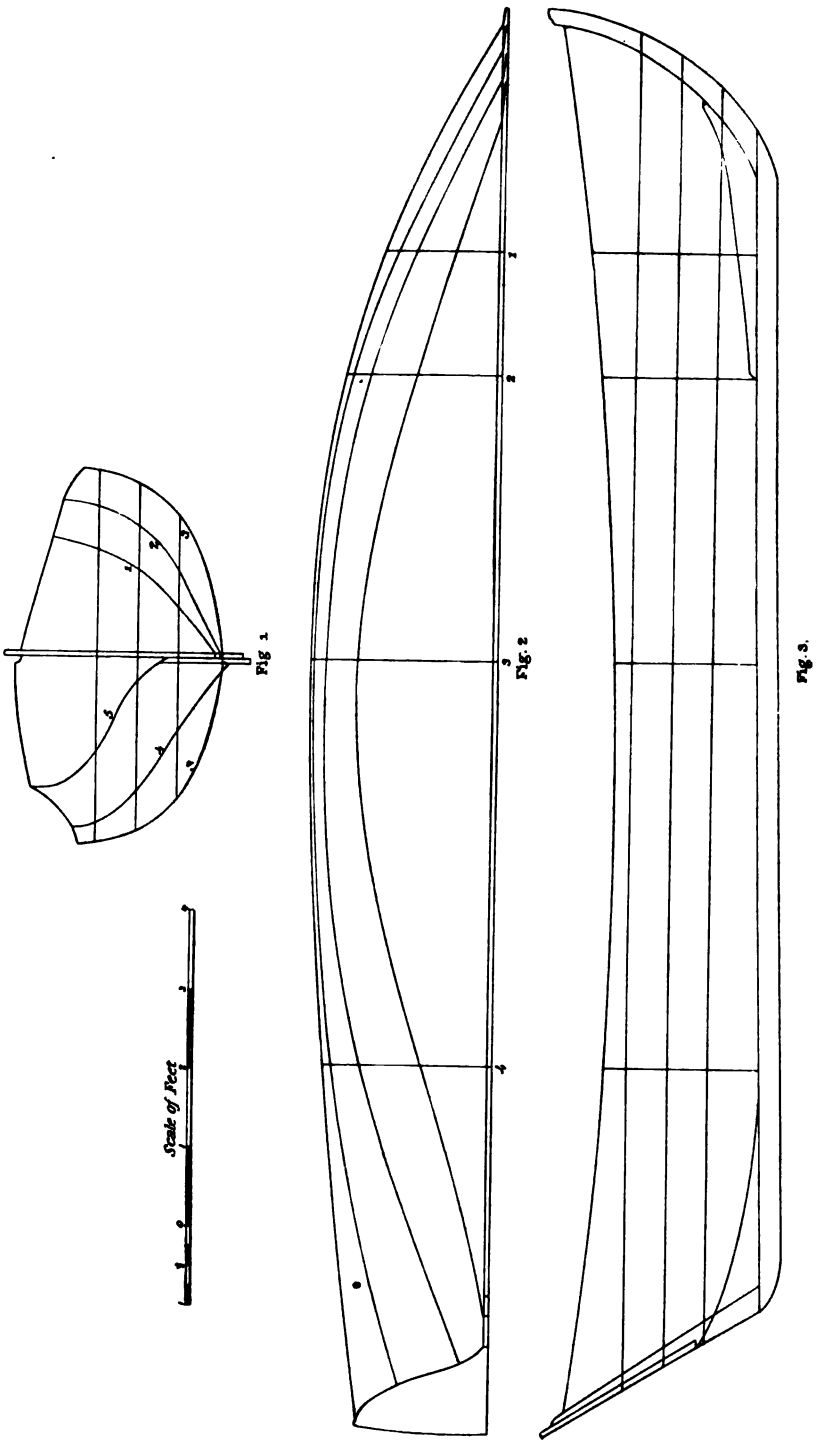
Length between perpendiculars	feet	150
Length over all	do	160
Breadth of beam	do	31½
Depth of hull	do	16
Tonnage, gross		512
Tonnage, net		343

The engines are single, direct-acting, with two boilers of the Scotch type. Either anthracite or bituminous coal may be used; 7 tons are consumed in 24 hours' steaming. The rate of speed is about 10 knots an hour. The propeller is non-hoisting, has two blades, and is made of yellow metal. In the ice it is protected by the stern and rudder posts, the blades being in a line. The planking is of oak and yellow pine. The bow is sheathed with three-eighths of an inch of yellow metal and solidly timbered. Provisions are made for 30 men in the crew, and the quarters are heated by pipes leading from the boilers.

II.—THE FUR-SEAL AND SEA-OTTER VESSELS AND BOATS.

5. *Vessels of San Francisco and Puget Sound.*—A fleet of considerable size is employed in spring and summer in pelagic fur sealing from San Francisco and ports on Puget Sound. These are all schooners, some of which have gone to the Pacific from New England and are of the type commonly used in the Atlantic sea fisheries, while others have been built on the west coast. There is considerable variation in the size of the vessels composing this fleet, ranging from 18 tons to more than 100 tons. Some of the vessels were engaged in the halibut fishery, as well as in sealing, in 1888 and 1889. Some vessels which engage in pelagic sealing during the spring and early summer find employment for a part of the season in hunting sea otters. Part of these are small schooners that are built in Alaska, and which have certain peculiarities.

6. *Alaskan schooners.*—The Alaskan coast is high and broken, as a rule, particularly in that region where the principal fisheries are carried on, and because of this the winds are generally very unsteady near the land. Often a vessel may lie becalmed for several minutes under a bold headland and suddenly be struck by a squall sweeping down from the hills, and with such force that the best seamanship is required to prevent her from capsizing. Again, she may be sailing along with an apparently steady breeze, when, without warning, the wind comes swirling around a point or headland (or the vessel runs into an "eddy breeze"), causing the sails to jibe before it is possible to



FUR-SEALING BOAT.

FIG. 1. Body plan.

FIG. 2. Half-breadth plan.

FIG. 3. Sheer plan.

touch a sheet or lower the canvas. These exigencies of navigation have caused some modification in the schooner-rigged vessels built or used in Alaska. Captain Tanner has alluded to this as follows:

Most of the sailing vessels of Alaska are schooner-rigged. The mainsail is generally triangular in shape, resembling the "riding" sail used by the Grand Bank fishermen. This prevents the use of a maingaff, however, which detracts greatly from the beauty of the rig. It is claimed by those who employ it that this pattern of sail is much safer in squally and otherwise rough weather, and that with it there is less danger of carrying away the mainboom or mainmast in jibbing. Its advantages are also said to be greater than those of the ordinary pattern in approaching the many dangerous bays and headlands on the Alaskan coast. It is possible that this style of mainsail may be better adapted to stormy weather, as it presents less area to the wind, but in an ordinary sailing breeze it labors under a great disadvantage in going to windward with schooners carrying a gaff to their mainsail. Furthermore, the New England fishermen enter harbors on the Atlantic Coast which are fully as dangerous as any in Alaska. The topmast of these schooners is a continuation of the mast above the eyes of the rigging. Should the topmast be carried away close to the rigging, an entirely new mast would have to be put in. No light sails are carried except the mainstay sail, which is set from the deck. A jib and a forestay sail comprise the head sails. The masts are far enough apart to admit of a fair-sized foresail, which is essential on account of the small size of the mainsail. These little schooners are excellent sea-boats, from the fact that they are very deep in proportion to their size, and therefore draw a good deal of water. They have a considerable dead-rise and drag-line. The wood chiefly used in their construction is Alaskan spruce and pine. The fastenings are of iron, galvanized iron having been employed during late years. The construction of these vessels, so far from ship-building centers and with so few facilities at hand, reflects much credit upon their designers and builders. (Explorations of fishing grounds of Alaska, etc., during 1888.)

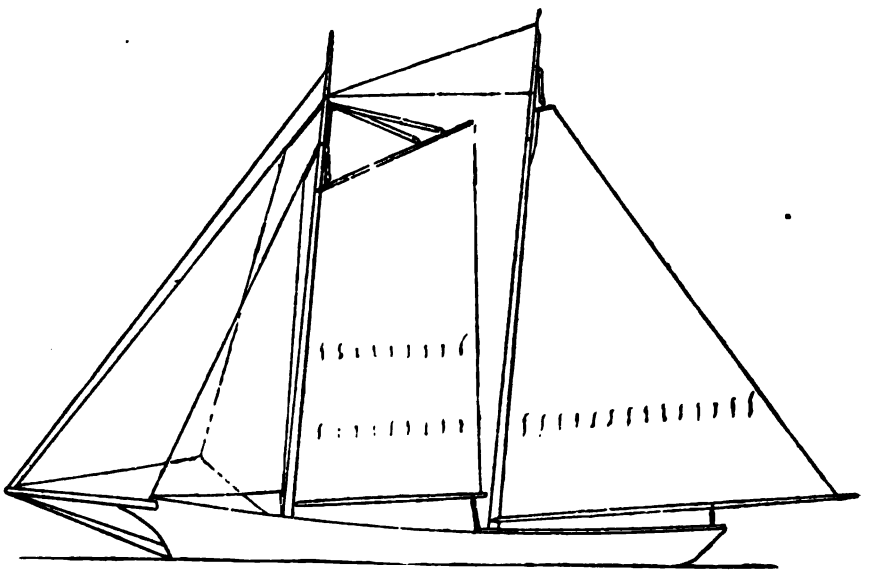


FIG. 1. Sail plan of Alaskan Schooner.

7. *Sealing boats.*—Hunting seals at sea has resulted in bringing into the Pacific fisheries a new type of boat, the sealing punt used at Toulinguet, Newfoundland. This boat is believed to be eminently well adapted to the needs of those who pursue the fur seal at sea. The first boats of this kind used on the Pacific, of which we have any

record, were built at Gloucester, Massachusetts, by Messrs. Higgins & Gifford, for Captain Solomon Jacobs, in the fall of 1887.

The following is a description of the type: It is an open, clinker-built, keel craft, with good sheer; sharp bow; strongly raking curved stem; rising floor; flaring topside; long easy run; heart-shaped stern; skag rounded on after corner. It is built of well-seasoned swamp cedar, on a light bent-oak frame, and combines lightness with strength and speed, while it has the eminently desirable quality of turning quickly and easily.

A variety of other types are used in connection with sealing and sea-otter-hunting, among which may be included the whaleboat, the dugout canoe of the Puget Sound region, and the skin bidarka of the Aleut. The dugout canoes and skin boats of this northwest coast are described in considerable detail in the following paragraphs:*

8. *Dugout canoes of Washington.*—The Makah Indians are famous fishermen, and they build and use dugout canoes extensively. The canoe of the Makah, be it large or small, usually has certain peculiarities of form which mark it as distinctive in type. There may be, sometimes, a considerable variation in form or in proportions, but the typical features are tolerably constant and easily recognized.

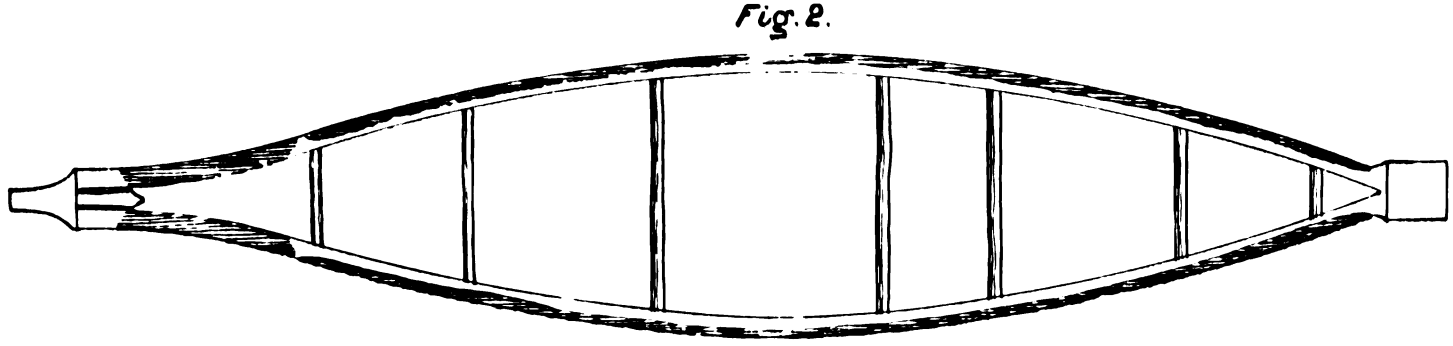
The Makah canoe from Neah Bay, Washington (now in the National Museum), and which is essentially the same in form as those used for halibut fishing and whaling, the chief difference being in size and equipment, may be thus described: It is sharp at both ends, with long, easy lines, a rather flat rounded bottom, flaring sides, the latter being carved so as to curve outward somewhat at the gunwale. The stern is vertically straight and has little if any rake. The bow, or cutwater (or what would be the stem on an ordinary boat), is curved strongly, and very closely resembles in shape the stem of a clipper fishing schooner; the upper part projects sharply forward and terminates in a long, pointed beak, which differs radically in shape from the bow of the Sitkan canoe. It has little sheer except at the ends. The beaklike bow rises with a pronounced but not excessive curve upward, while there is a quick upward turn at the extreme stern, which cannot be termed a sheer, but forms a sort of knoblike elevation where, in a common boat, the top of the sternpost would be. Elliott thinks that these projections are only for the single purpose of ornamentation, and this seems probable where there is no actual addition to the sheer of the canoe.

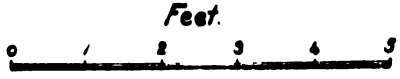
The following are the dimensions of this canoe:

	Feet.	Inches.
Length over all	15	5½
Beam, extreme	3	0
Depth, amidships	1	2
Height, amidships, gunwale to bottom of floor	1	3
Height of stern	2	0
Highest point of bow	2	9
Thickness of gunwale		1
Length of paddles, each	4	8
Width of paddle blade	0	7

The Clyoquot and Nittinat tribes or clans on Vancouver Island are expert in constructing canoes, made on the same model as those used by the Makahs; indeed, the latter often buy their boats, especially the larger ones, from the island tribes.

*The descriptions that follow are extracted from an unpublished report on fishing craft prepared by the writer, to which reference has previously been made.





WASHINGTON DUGOUT CANOE.

Fig. 1. Sheer plan.

Fig. 2. Plan of top.

The shaded portion is black.

Fig. 3. Cross section

PLATE VII.

The following notes on the construction of the canoes used by the Makah Indians of Cape Flattery, Washington, are from the writings of Swan:

A canoe-maker's stock of tools is quite small, consisting only of an axe, a stone hammer, some wooden wedges, a chisel, a knife, and a gimlet. Those so fortunate as to possess a saw will use it occasionally; but the common method of cutting off a piece of wood or a board is with the axe or chisel. And yet with these simple and primitive tools they contrive to do all the carpenter work required. Canoes of the medium and small sizes are made by the Makahs from cedar procured a short distance up the strait or on the Tsuess River. After the tree is cut down and the bark stripped, the log is cut at the length required for the canoe, and the upper portion removed by splitting it off with wedges until the greatest width is attained. The two ends are then roughly hewed to a tapering form and a portion of the inside dug out. The log is next turned over and properly shaped for a bottom, then turned back and more chopped from the inside, until enough has been removed from both inside and out to permit it to be easily handled, when it is slid into the water and taken to the lodge of the maker, where he finishes it at his leisure. In some cases they finish a canoe in the woods, but generally it is brought home as soon as they can haul it to the stream.

Before the introduction of iron tools, the making of a canoe was a work of much difficulty. Their hatchets were made of stone, and their chisels of mussel shells ground to a sharp edge by rubbing them on a piece of sandstone. It required much time and extreme labor to cut down a large cedar, and it was only the chiefs who had a number of slaves at their disposal who attempted such large operations. Their method was to gather around a tree as many as could work, and these chipped away with their stone hatchets until the tree was literally gnawed down, after the fashion of beavers. Then to shape it and to hollow it out was also a tedious job, and many a month would intervene between the times of commencing to fell the tree and finishing the canoe. The implements they use at present are axes to do the rough hewing and chisels fitted to handles; * * * these last are used like a cooper's adze, and remove the wood in small chips.

The process of finishing is very slow. A white carpenter could smooth off the hull of a canoe with a plane, and do more in two hours than the Indian with his chisel can do in a week. The outside, when it is completed, serves as a guide for finishing the inside, the workman gauging the requisite thickness by placing one hand on the outside and the other on the inside and passing them over the work. He is guided in modeling by the eye, seldom if ever using a measure of any kind; and some are so expert in this that they make lines as true as the most skillful mechanic can. If the tree is not sufficiently thick to give the required width, they spring the top of the sides apart, in the middle of the canoes, by steaming the wood. The inside is filled with water which is heated by means of red-hot stones, and a slow fire is made on the outside by rows of bark laid on the ground a short distance off, but near enough to warm the cedar without burning it. This renders the wood very flexible in a short time, so that the sides can be opened from 6 to 12 inches.

The canoe is now straightened, and kept in form by sticks or stretchers similar to a boat's thwarts. The ends of these stretchers are fastened with withes made from tapering cedar limbs, twisted and used instead of cords, and the water is then emptied out; this process is not often employed, however, the log being usually sufficiently wide in the first instance. As the projections for the head and stern pieces cannot be cut from the log, they are carved from separate pieces and fastened on by means of withes and wooden pegs. A very neat and peculiar scarf is used in joining these pieces to the body of the canoe, and the parts are fitted together in a simple and effectual manner. First the scarf is made on the canoe; this is rubbed over with grease and charcoal; next the piece to be fitted is hewn as nearly like the scarf as the eye can guide, and applied to the part which has the grease on it. It is then removed, and the inequalities being at once discovered and chipped off with the chisel, the process is repeated until the whole of the scarf or the piece to be fitted is uniformly marked with the blackened grease. The joints are by this method perfectly matched, and so neat as to be water-tight without any calking.

The head and stern pieces being fastened on, the whole of the inside is then chipped over again, and the smaller and more indistinct the chisel marks are the better the workmanship is considered. Until very recently it was the custom to ornament all canoes, except the small ones, with rows of the pearly valve of a species of sea snail. These shells are procured in large quantities at Nittinat and Clyoquot, and formerly were in great demand as an article of traffic. They are inserted in the inside of the edge of the canoe by driving them into holes bored to receive them. But at present they are not used much by the Makahs, for the reason, I presume, that they are continually trading off their

canoes, and find that they bring quite as good a price without these ornaments as with them. I have noticed, however, among some of the Clallams, who are apt to keep a canoe much longer than the Makahs, that the shell ornaments are still used. When the canoe is finished it is painted inside with a mixture of oil and red ocher. Sometimes charcoal and oil are rubbed on the outside, but more commonly it is simply charred by means of long fagots of cedar splints, set on fire at one end like a torch, and held against the side of the canoe. The surface is then rubbed smooth with a wisp of grass or a branch of cedar twigs. When the bottom of a canoe gets foul from long use, it is dried and charred by the same process.

The paddles are made of yew, and are usually procured by barter with the Clyoquot Indians. The blade is broad like an oar blade, and the end rounded in an oval or lanceolate form. The handle is a separate piece fitted transversely with the length of the paddle, and sufficiently long to afford a good hold for the hand. These paddles when new are blackened by slightly charring them in the fire, and then rubbed smooth and slightly polished.

The sails were formerly made of mats of cedar bark, which are still used by some of the Clyoquots, although most of the tribes in the vicinity now use cotton. The usual form is square, with sticks at the top and bottom like a vessel's yards; a line passes through a hole in the top of the mast, rigged from the lower stick, and the sail is easily and quickly hoisted or lowered. When taken in it is rolled round the lower yard, and can be enlarged to its full size or reduced to adjust it to the force of the wind. Some Indians have adopted sprit-sails, but they are not in general use, nor are they as safe or convenient for the canoe as the square sail.

In cruising on the Strait they usually keep well inshore, unless they intend to cross to the opposite side; and if the canoe is large and heavily laden they always anchor at night, and for this purpose use a large stone tied to a stout line. Sometimes they moor for the night by tying the canoe to the kelp. When the craft is not heavily burdened it is invariably hauled on the beach whenever the object is to encamp. If the wind is fair, or they have white men on board, they will travel all night, but on their trading excursions they usually encamp, which causes much delay in a long journey. I have been seven days, in the winter season, making the passage between Neah Bay and Port Townsend, about 100 miles, and in the summer have made the same trip in but little over 24 hours. The average passage, however, is about three days for the distance named, which includes camping two nights.*

Wilkes, who visited the Northwest something more than half a century ago, seems to have been much impressed with the canoes he saw there, and particularly so with the ingenious manner in which the natives repaired their boats. He makes the following statements:

The canoes of this region [Oregon] differ from anything we had seen on the voyage. They were made from a single trunk and have a shape that may be considered elegant, and which is preserved from change from stretching or warping by means of thwarts. The sides are exceedingly thin, seldom exceeding three-fourths of an inch, and they are preserved with great care, being never suffered to lie exposed to the sun for fear of rents and cracks. When these do occur, the canoe is mended in a very ingenious manner: holes are made in the sides, through which withes are passed and pegged in such a way that the strain will draw it tighter; the withe is then crossed and the end secured in the same manner. When the tying is finished, the whole is pitched with the gum of the pine. This is neatly done, and answers the purpose well. †

The fishing canoes are generally propelled only by paddles, and are usually provided with fishing lines made of kelp or sinew, baskets in which spare hooks and lines are kept, a number of the peculiar halibut hooks used by the Indians, and clubs for killing the fish.

In recent years, since pelagic fur-sealing has been prosecuted from the Puget Sound region, Indians have often constituted a large portion of the crews of sealing vessels, and these have generally preferred the light dugouts for chasing seals.

* "The Indians of Cape Flattery" (Smithsonian Contributions to Knowledge), by J. G. Swan.

† Narrative of the United States Exploring Expedition, 1838–1842, by Commander Charles Wilkes, U. S. N., vol. IV, page 300.

The canoes used for whaling are the largest, ranging from 35 to 40 feet in length; they usually carry a crew of 8 men. They are well supplied with harpoons, lances, whale-lines, etc. An important part of their equipment are the floats, made of inflated bladders of sea-lions, which are used as buoys and are attached to the whale lines after the whales are struck. A canoe of this kind complete is worth $250.

The dugouts employed in the cod and halibut fisheries rank next in size to those used for whaling; they are mostly from 30 to 33 feet long and about 5 feet beam. The crew of a canoe is commonly from 4 to 5 persons; cost, about $50. Sealing canoes range from 20 to 22 feet in length; average 2½ feet beam; value $25 each. Salmon canoes about 10 feet long; 2½ to 3 feet wide; operated by one man; average value $10.

9. *Dugout canoes of Alaska.*—No people in the world are more dependent upon boats than are the natives of southeastern Alaska. Living in a region where the coast line is broken into many channels, straits, and harbors by the numerous islands of the Sitkan Archipelago; where the land offers little to reward the skill or perseverance of the hunter, and the supplies of food and other necessaries must be drawn from the sea, the possession of serviceable boats is of more than ordinary importance to the inhabitants. Well may Elliott say that "the one thing of joy, of delight, and of infinite use to the native of the Sitkan Archipelago is his canoe. Life, indeed, would be a sad problem for him were it not for this adjunct of his own creation. Upon its construction he lavishes the best of his thought, the height of his manual skill, and his infinite patience. The result of this attention is to fashion from a single cedar log a little vessel which challenges our admiration invariably for its fine outline and its seaworthiness and strength."*

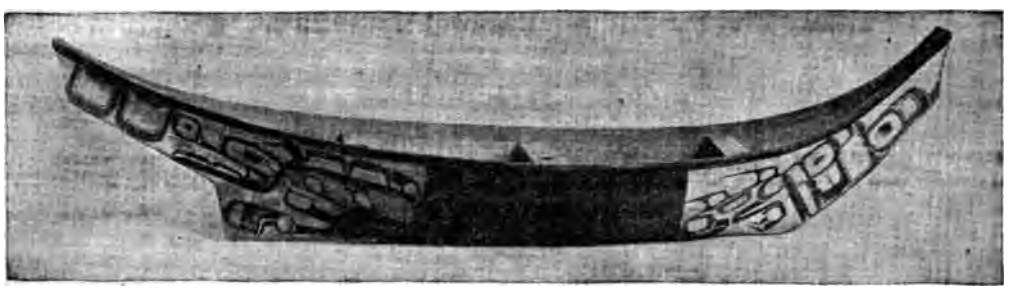


FIG. 2. Alaskan Dugout Canoe.

The Indians of the Sitkan region, like many other savages, have shown much skill in modeling their canoes, and have apparently by intuition solved successfully the difficult problems of least resistance, buoyancy, and requisite stability—qualities essentially necessary in a working boat, but the proper combination of which has often put to the severest test the constructive skill of the most experienced white men. These natives have also shown the usual adaptation of means to ends characteristic of savages, and although the land fails in a large measure to supply their other wants, the timber with which it abounds has been well and skillfully utilized in the manufacture of their canoes. All the tribes or clans in the Sitkan Archipelago use dugout canoes, the size of which varies from 10 or 12 feet to upward of 30 feet in length; the usual length of a

*"Our Arctic Province," by Henry W. Elliott, page 62.

fishing canoe is 15 to 20 feet.* There is a marked family likeness in all these canoes, so far as form and construction are concerned, but in addition to the difference in size just alluded to, they also vary somewhat in details of shape, or, as one might say, in model.

An indigenous, coniferous tree (*Abies sitkensis*), a species of pine, is used to a large extent in the manufacture of these boats, while the giant cedar (*Thuja gigantea*) is also utilized for the same purpose. Of the latter Elliott says:

> The wood is light, durable, and worked very readily; but it is apt to split parallel to its grain. This constitutes the only solicitude of the Indian's mind. He keeps the canoe covered with mats and brush whenever it is hauled out, even for a few days, to avoid this danger, for whenever a canoe is heavily laden, and working as it will do in a rough channel, it is in constant danger of splitting at the cleavage lines of its grain, and thus jeopardizing its living as well as dead freight.

According to the same authority only the largest canoes are made of cedar, probably because of the danger from splitting; the medium-sized and smaller boats are constructed of pine, the Douglas pine (*A. douglasi*) being extensively used on Prince of Wales Island, where this species grows in profusion.

The method of construction is essentially the same as that adopted by the Makah Indians and need not be repeated in detail. The natives of Alaska employ fire in excavating their canoes. They first dig a small trench longitudinally through the middle, and having made sufficient chips for the purpose, they set fire to them in one end of the boat. When the wood in that end is charred enough to make the working of it comparatively easy, the fire is transferred to the opposite end and the workman proceeds to excavate the part that has been burned. This process is repeated over and again until the bulk of the interior wood has been removed. It would not be safe to use fire too long, for in the last stages of the work the boat might be ruined by being burned through. The adze is therefore depended upon to complete the work of excavation and to bring the boat down to the requisite thickness.

To obtain the desired pliability, so that the boats may be spread out and thus made wide enough to insure the necessary stability, they are steamed by first filling them about one-third full of water and then putting hot stones into the water, care being taken to cover the boat with cedar mats to prevent the escape of the steam. When this process has been continued long enough the gunwales are forced apart and to hold them in proper position the thwart-sticks or gunwale spreaders are inserted and securely lashed in place. After this the canoe is painted or otherwise ornamented.

Elliott says:

> Canoes are smoothed outside and painted black, with a red or white streak under the gunwale in most cases; inside they bear the regular fine tooth-marks of the excavating adze, and are smeared with red ochre. The paddles are usually made of yellow cypress, and a great variety of small wooden bailing dippers are also provided, one or two for each canoe, because the water often slops over the gunwales in bad weather. The canoe itself is never suffered to leak. The average size is one of 15 to 20 feet in length, which will carry from eight to ten savages, with baggage. One having a length of 30 to 35 feet carries as many men. The smaller canoes of from 12 to 13 feet are usually used by one or two savages in their quick irregular trips to and from the village, and are easily launched and hauled out by one man.

The special features that characterize the canoes of the Sitkan region are easily recognizable, although, perhaps, not entirely confined to boats of this locality. Its chief peculiarity is in the bold upward curve of its ends, and particularly in the

*Elliott tells me that the great war canoes that were formerly made, and which often were 50 to 60 feet in length, are no longer built, since for many years there has been no use for a boat of this kind. He thinks it is seldom that a canoe exceeds 25 or 30 feet in length at the present day.

remarkable overhang at the bow. Indeed, the average white man would, unless informed on the subject, think that the bow was the stern and the stern the bow. Both ends are sharp, and often the canoes have long, graceful, easy lines—sometimes made on the "wave system"—that are well adapted to speed.

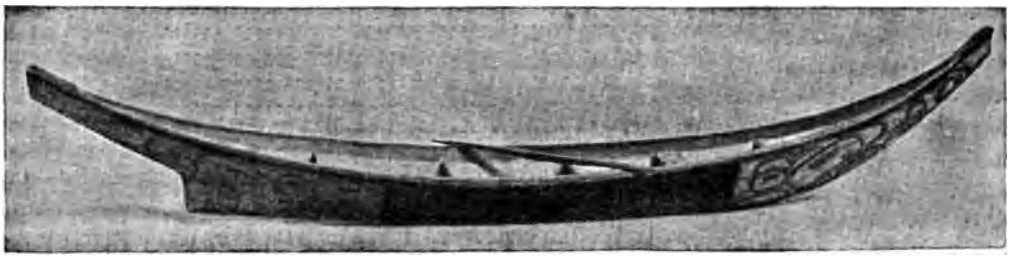


FIG. 3. Alaskan Dugout Canoe.

A full-sized specimen of the Alaskan dugout canoe, now in the National Museum, may be thus described: It is made of cedar (*Thuja gigantea*); is sharp at both ends, with easy, slightly hollow water lines, and very little sheer except at the extreme ends, which curve abruptly upwards. It has a narrow, nearly flat bottom, that is rounded a very little, and tapers to a point at each end; the sides are strongly flaring, and moderately curved, and this flare is carried out in the bow and stern, both of which have nearly the same angle of rise that is given to the midship section. The bow, which is characteristic of this class of dugouts, is distinctive in type and unlike the bow of any other boat we are familiar with. The forefoot is thin, like the after skag of an ordinary boat, its forward side being vertical, or nearly so, forming a right angle with the bottom, and extending upwards about 1 foot. Above and beyond this square-cornered forefoot the bow projects strongly forward and upward, forming a snout-like appendage between 3 and 4 feet in length,* with a sharp, cutwater edge below and with a varying width above, the extreme end being cut vertically, so that it shows a V-shaped section, the angles of which are nearly equal, and each about 7 inches in length. It will thus be seen that the flare of the side is carried out to the extreme point of the bow. The point of this projection, for about a foot in length, is painted in fantastic design, three colors, red, blue, and black, being used. These designs, like those on the totem posts, are supposed to have some symbolic meaning.

The stern has a strong rake and flare, with gradual upward curve below, like the forward end of a sled runner, the general form resembling somewhat the so-called "scoop-shaped" bow characteristic of certain types of Scandinavian fishing craft. The top of the stern curves sharply upward, and its extremity is squared off like that at the bow and forms a similar V-shaped section. The stern is carved to resemble somewhat a boat which has a curved stern-post, a decided hollowing out being apparent about 3 to 4 inches from the after edge. This canoe has the following dimensions:

	Feet.	Inches.
Length, over all	27	10
Beam, extreme	3	8
Depth, inside amidships	1	5¼

*The length of these projections varies in different canoes of essentially the same size, and in one of 25 to 30 feet in length the bow may range from a little over 3 feet to upward of 5 feet projection.

A small dugout from the same region (also in the National Museum) has the same characteristic features, but differs in proportions and in having a strong and tolerably symmetrical sheer throughout her length, also in being painted uniformly black; it has the following measurements, which represent the minimum for dugout canoes of Alaska:

	Feet.	Inches.
Length, extreme	8	10
Beam, extreme	2	2½
Depth, amidships		11½
Height at bow	1	7½
Height at stern	1	10

These canoes are most commonly propelled with paddles, with lanceolate-shaped blades, and often highly ornamented. Sometimes a small sail is used, and running with a free wind they will make good speed, but having no keel they can not, of course, make much progress to windward. They set lightly on the water, and move easily, and the natives paddle them with considerable rapidity.

III.—SKIN BOATS.

10. *Geographical distribution.*—Over the greater part of the United States and the Territories skin boats are little used or entirely unknown. The aborigines of the east and west coasts, as well as those living near the inland waters—the lakes and rivers that intersect the country in various directions—have generally found at their command, and more easily obtainable, other material as well or better adapted to the building of boats, while skin suitable for this purpose could not be secured in most cases. It is only in the colder regions, where timber or bark is scarce or entirely absent, and where the native hunter usually has little difficulty in capturing the seal, sea lion, and walrus, that skin boats are extensively or universally employed, these animals furnishing the material best adapted to the construction of such craft. Thus, while we find that only one type of skin boat—the so-called "bull-boat" made of buffalo hide—has been used in the temperate latitudes of the United States, the coast natives of western and northern Alaska—"our Arctic province"—depend almost entirely upon canoes made from the skins of various marine mammals.

A large number of skin boats of various patterns are used in the fisheries pursued about the Aleutian Islands and elsewhere on the Alaskan coast. These may be broadly classified into two types: First, the kaiak, to which the name of bidarka has been applied by the Russians, and largely adopted by the natives of the Aleutian islands; second the oomiak, or woman's boat, also known as the baidar or bidarrah. The former is used chiefly for fishing, hunting the sea-otter, killing seals, walrus, and whales, and is specially constructed for speed and easy management. It is now employed to some extent in salmon fishing. The bidarrah is much larger and of a bulkier pattern, and generally is employed for transportation and for the use of women and children, who are not supposed to be as skillful as the men in the management of a boat. Indeed, this big canoe is used for such work as the smaller and lighter bidarka is not suitable for. In some parts of Alaska it is employed in whaling.

11. *The kaiak or bidarka of Alaska.*—There are several types of kaiaks used in Alaska, differing both in size and form, and sometimes in the material of which they are constructed. It is not within the province of these notes to enter into an elaborate

or exhaustive treatise on the peculiarities of the various forms. The subject is an interesting one and, from an ethnological point of view, deserves the fullest consideration. At another time the writer hopes to do it justice; but here nothing will be attempted beyond a description of the more important types, as illustrative of the skin boats employed in the Alaskan fisheries.

At Kadiak, throughout the Aleutian Islands, and thence northwardly along the mainland coast, the kaiak or bidarka is extensively used, and in most parts of this region the natives could not support life without it. Indeed, in some localities of the north the ability to build a kaiak marks an important point in the life of the coast native. Petroff says:

> The youth as soon as he is able to build a kaiak and to support himself, no longer observes any family ties, but goes where his fancy takes him, frequently roaming about with his kaiak for thousands of miles before another fancy calls him to take a wife, to excavate a miserable dwelling, and to settle down for a time.*

In some sections of Alaska kaiaks with only a single manhole are exclusively used, but along the greater part of the coast, and especially in the Aleutian group, bidarkas with two or three manholes are common, although even there, smaller ones, made to carry only a single occupant, are found. It is probable that the true kaiak—the smaller canoe with a single hole—was the original form of the covered skin boat, and some authorities say that this is in accordance with a tradition of the natives of Attu, the westernmost island of the Aleutian Chain.

The larger boats of this class, having two or three manholes—those to which the name bidarka is most properly applied and which are in most common use for commercial fishing—were invented by the Russians, according to some excellent authorities, who, after their occupation of trading posts in Alaska, built, or induced the natives to build, these larger skin canoes that they might carry more men. But they were not able to otherwise improve upon the kaiak in construction or model. Indeed, the Russians esteemed these skin boats so highly that they at once adopted them to the exclusion of all others for navigating those waters;† and they appear to have taken them further south, when they established trading posts in California, where their use is mentioned by Wilkes.‡

Turner, who has given much attention to the history of the skin boats of Alaska, believes that only single-hole kaiaks were made by the natives previous to the advent of white men. He says there was no occasion for the larger canoes, or bidarkas, which the demand for sea-otter skins and the necessity for traders to make long journeys by water, with native boatmen, called into existence. But opinions differ on this subject, and we can give here only some of these, and thus open up the question for discussion by those who, from experience and observation, are best fitted to furnish the facts.

Elliott, whose study of Alaska entitles his opinions to much respect, thinks that long before Alaska was visited by the Russians the Aleuts built and used kaiaks with two holes at least. He bases this opinion on the fact that these natives have always engaged in sea-otter hunting and in whaling, and for these enterprises it is essential to have a canoe which will carry two men. This, he believes, will be easily understood, and

*Alaska, volume 8, Tenth Census, by Ivan Petroff, page 135.

†Bancroft's "Native Races of the Pacific States," 1, 61.

‡"Narrative of the U. S. Exploring Expedition," 1838 to 1842, by Commander Wilkes

[illegible] reasonable, when the methods of [illegible] Aleuts, are studied. In pursuance [illegible] together in the same boat; the one [illegible] while the other throws the spear [illegible] thinks, that skin canoes with [illegible] peculiar occupation. He says:

[illegible] them are made with two manholes [illegible] skinners always go in pairs or [illegible]

Dall says:

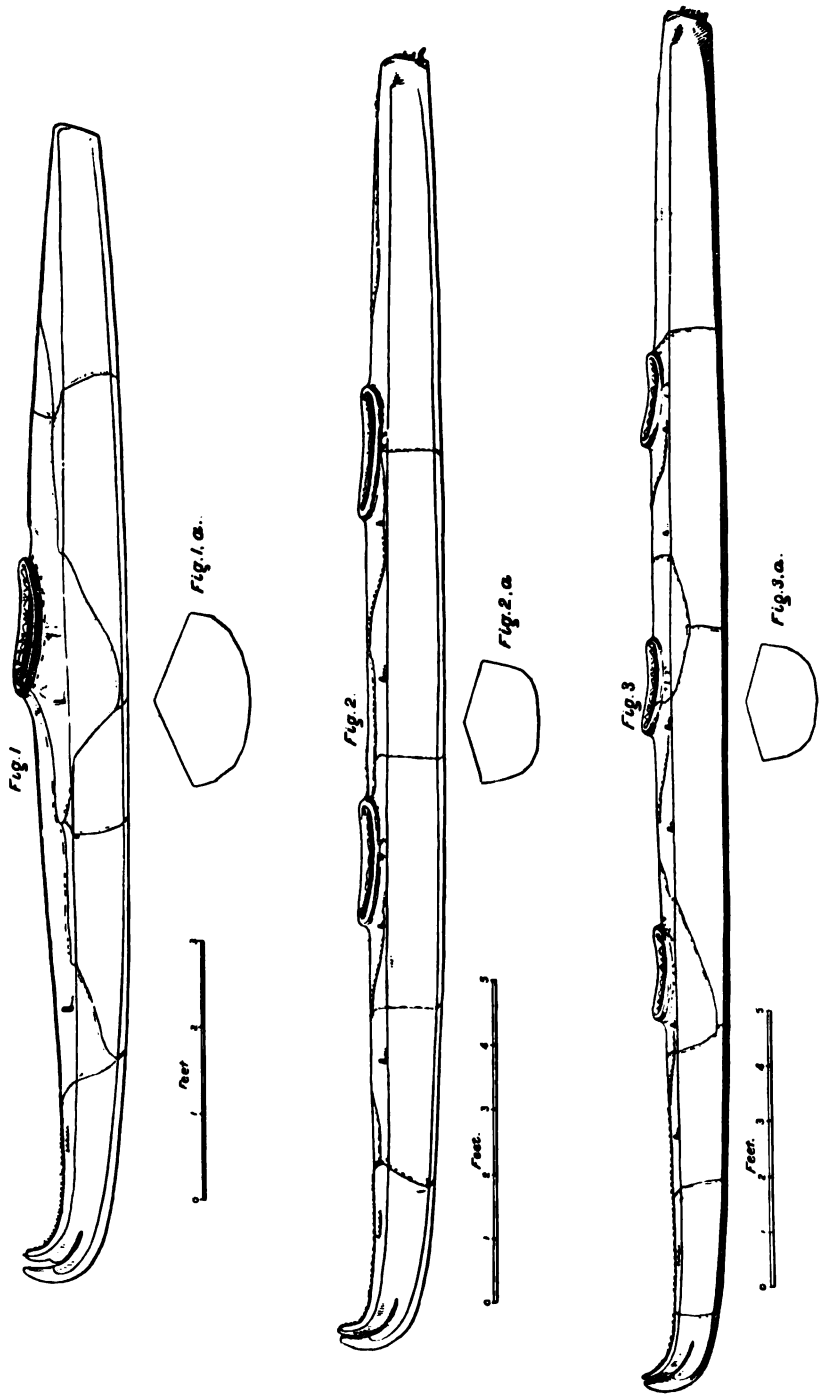
[illegible] umiaks are [illegible] I have stated that the large canoes [illegible] of the Territory, however, [illegible] the Eskimo is evidently [illegible] universal among the kaiak-using [illegible]

[illegible] are many types of these skin-boat [illegible] Aleuts, all [illegible] doubtless of Eskimo origin, [illegible] notice that typical differences [illegible] 1896, [illegible] deck resembles the kaiak [illegible] Hall; Ignitok, [illegible] with a moderate dome shape [illegible] Tuttle, [illegible] Kadiak. Petroff [illegible] Kaiakalik River. The [illegible] 1880, [illegible] descriptive [illegible]

[illegible] resemble the kaiaks [illegible] Yukon. With the [illegible] skins were [illegible] Aleuts [illegible] kaiaks are, but [illegible]

[illegible] Nushagak Eskimo [illegible] Nushagak [illegible] Eskimo [illegible] Yukon [illegible] Nushagak [illegible]

[illegible]



BIDARKAS.

FIG. 1. Sheer plan of single-hole bidarka.
FIG. 1a. Cross section.

FIG. 2. Sheer plan of two-hole bidarka.
FIG. 2a. Cross section.

FIG. 3. Sheer plan of three-hole bidarka.
FIG. 3a. Cross section.

13. *Aleutian bidarkas.*—The Aleutian bidarka is one of the most noticeable of the skin boats in Alaska. Both two-hole and three-hole bidarkas are used by the Aleuts, as well as the single-hole canoes. The two-hole bidarka is, however, most commonly employed in the sea-otter and whale hunt and in the cod and halibut fishery, and may therefore be properly selected as the type upon which to base description.

The frame of a bidarka is composed of light pieces of driftwood and small withes which are firmly lashed together with sinews so as to stiffen the whole fabric. It is said that recently rattan is used to some extent in the frames of bidarkas, this light, elastic, serviceable material being obtained for the natives by the traders on the coast. A strip runs the entire length of the bottom and forms a keelson or inside keel. On each side are generally three small strips or battens, which extend from end to end of the boat and divide into nearly equal sections the space between the keel at the bottom and the gunwale. The gunwale is a wider strip, which also extends from end to end in a similar manner. These battens are brought together and properly lashed at the bow, and are also sprung in at the after part and fastened to a peculiar, flat, projecting sternpost, which is perforated with holes to receive the seizings of sinew that confine the ends of the strips. Inside of these battens are the ribs of the canoe, these being light and deftly bent to fit into their several places. It is said by Turner that, in preparing these for a canoe, the native often passes the strip through his mouth and by biting it makes the stick bend without breaking it, obtaining by this primitive method a result similar to that secured by a carpenter who makes saw cuts in a piece of wood that he desires to bend. The battens are securely held in place by the ribs and these assist in preventing the skin covering from being sprung in by the pressure of the water on the outside of the bidarka.

The frame is covered with the untanned or green skins of the sea lion, which have been unhaired by a sweating process. These hides are drawn over the skeleton, deftly sewed, and properly secured in place while they are wet and pliable, and the entire boat, top and all, is covered with the exception of the two manholes, which are placed near the middle, in the most convenient positions for the occupants of the boat.

"When the skins dry out, they contract and bind the frame and are as taut as the parchment of a well-strung bass-drum. Then the native smears the whole over with thick seal-oil, which keeps the water out of the pores of the skin for quite a long period and prevents the slackening of the taut binding of the little vessel for 24 to 30 hours at a single time. Then the bidarka must be hauled out and allowed to dry off in the wind, when it again becomes hard and tight."*

A canoe is reoiled whenever it is hauled out and dried, and it is never left floating in the water when not in actual use. The bidarka has a round, keelless bottom, flaring sides, comparatively little sheer, except at the bow, where it has an abrupt upward curve. It is long, narrow, and has fine-lined sharp ends, its form being remarkably well adapted to speed, while it is known to be one of the best sea-boats in the world, under the skillful management of the brave and dexterous Aleuts. The stern is generally, if not always, nearly vertical, while the bow, on its lower and outer edge, as well as above, curves upward, its shape resembling somewhat that of the fore end of a long, tapering sled-runner.

A curious feature of an Aleutian bidarka is that its bow is divided into two parts,

* Our Arctic Province.

which might be likened to the mouth of an animal having a curved, sharp-pointed snout. Elliott claims that this form of bow is purely conventional with the Aleuts, who build their boats that way simply because they have never built them differently. Turner, however, says that this style has been adopted because the natives believe that it makes the skins stretch better when they are putting them on the frame, and also because it offers a convenient hand grasp when pulling the canoe out of the water. An additional reason is that it makes the bow more elastic and relieves the shock when the bidarka suddenly strikes the shore.

The Aleutian bidarka is propelled wholly by double-bladed paddles, and the lances, harpoons, and other implements are held in place underneath strips of seal or walrus hide, which extend from side to side over the deck of the boat.

The length varies slightly, but the following are about the average dimensions of a two-hole bidarka: Length, 17½ feet; beam, 2 feet; depth, 15 to 16 inches.

As previously stated, the top of a bidarka is entirely covered, or decked, except the manholes, around which is a skin-covered wooden rim, about 2½ or 3 inches high, which not only serves the purpose of a coaming to this circular hatch, but permits the occupant to secure around it the lower part of his water-proof garment, a sort of hooded frock called kamleika, in such manner that no water will get into the kaiak, however much may go over her and her crew.* The kamleika is used only in the roughest weather, and at other times the natives use a sort of circular apron, the lower edge of which is fastened around the rim of the manhole while the upper part is drawn tightly about the waist by a gathering-string.

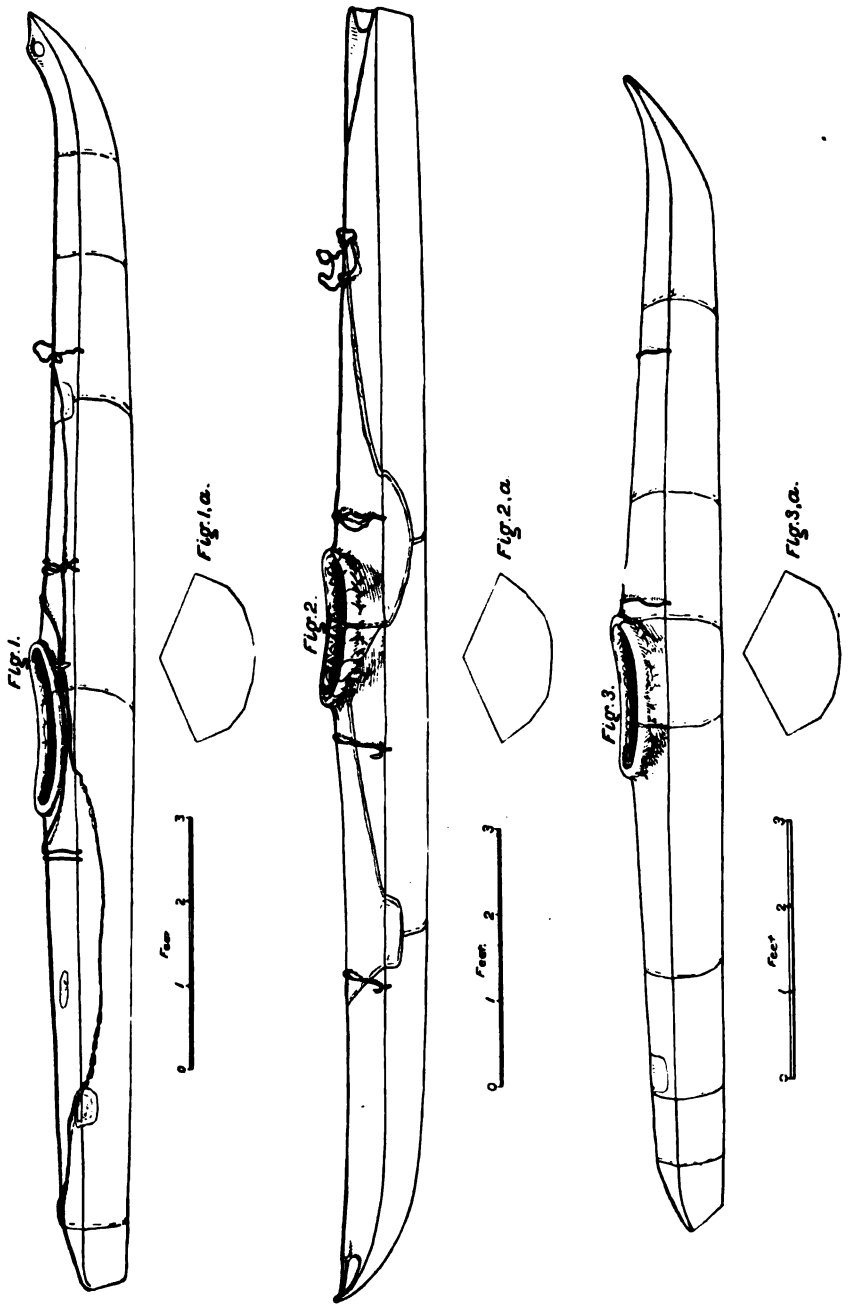
When the natives engage in cod-fishing a single individual goes in a two-hole bidarka. He usually sits in the after manhole, and his fish are thrown into the forward opening, until his cargo is obtained. In halibut-fishing two bidarkas are used, placed near each other, side by side, the paddles laid across from one to the other, so as to form a sort of double boat. This is necessary to prevent the canoes from being capsized by the vigorous struggles of this large fish; it also offers the occupants of one of the bidarkas the opportunity to club the fish near it while it is being pulled up by the native in the other boat. Usually, in this case, two men go in each canoe, but at least two in one, so that the individual not otherwise engaged exerts himself to hold the paddles firmly in order to prevent an upset, which otherwise would take place.

The two-hole bidarka (fig. 2, plate VIII) is the one *par excellence* for hunting the sea otter, and probably in no other boat of its size do men take more frightful risks than are taken by the Aleutian sea-otter hunters.†

* Petroff, in writing of the natives of Kadiak Island, remarks in regard to this garment:

"The kamleika is the most important article of clothing worn by the Kaniags, as it protects them against rain and moisture, and without it it would be impossible to undertake any extended voyages in bidarkas. It is made from the entrails of bears, sea-lions, or seals, occasionally also of those of the sea-otter. These are dried, cut into long strips, and sewed together into shirts with wide sleeves, and a hood which is drawn over the head until only a portion of the face remains bare."

† See description of sea-otter hunting, by H. W. Elliott, in "Our Arctic Province," page 142. Captain Slocum says that experience and necessity have taught the Aleut a very important lesson in seamanship. When the native is going out where there is a heavy sea and a strong wind blowing, he puts one or more stones in the bow of his canoe to trim it a little by the head. The object is to make it easier and more certain to bring the bidarka suddenly head to a breaking wave, and also to prevent the bow from raising so high above the crest of a sharp sea as to make the boat fall off side to the wind, in a dangerous position.



TYPES OF ALASKAN KAIAKS.

FIG. 1. Kaiak from King's Island.
FIG. 1a. Cross section.

FIG. 2. Kaiak from St. Michael's.
FIG. 2a. Cross section.

FIG. 3. Kaiak from Cape Espenberg.
FIG. 3a. Cross section.

The three-hole bidarka of the Aleuts and adjacent tribes differs from that of the two-hole chiefly in its size and in having the additional manhole. This type of canoe is used very little in the fisheries, being a boat designed chiefly for cruising or carrying white traders about the country. The following are the dimensions of the bidarka of this class now in the National Museum:

	Feet.	Inches.
Length, over all	24	8
Beam	2	3
Depth, from top of manhole rim	1	1¼
Height of rim of manholes	..	1¼–1½
Width of manhole	1	10½

The canoe from which these measurements were taken was used on the revenue cutter *Corwin* in making her explorations in Alaska and Bering Sea. See fig. 3, plate VIII.

Skin boats with a single manhole are used for certain purposes. These differ from the two-hole and three-hole bidarkas chiefly in being wider and deeper in proportion, since the larger boats gain in dimensions almost entirely by additional length. One of these kaiaks which is in the National Museum has the following dimensions: Length, extreme, 13 feet 10 inches; beam, 2 feet 5 inches; depth in manhole, top of rim to bottom, 16 inches. This canoe (fig. 1, plate VIII) has the typical split bow of the Aleutian bidarka, a dome-shaped or strongly arched deck, and a hogback sheer, the boat being highest in the middle and gradually slanting downward to the ends, except at the extreme bow where it has an abrupt upward curve.*

The frame is as follows: The keelson in the middle of the bottom extends from end to end of the boat, and between this and the gunwale on either side are four battens, running longitudinally, and separated from each other from 2½ to nearly 4 inches. These battens or rib bands are made of wood, as is all the frame, and are from three-fourths to seven-eighths inch wide, and three-eighths to one-half inch thick. The keelson and the gunwales are a trifle heavier. The ribs are flat, or nearly so, 3 inches by one-fourth inch, bent around from gunwale to gunwale, inside of the battens, and each is held by a seizing of sinew around the keelson, while its upper ends are inserted into holes in the underneath side of the gunwales. The deck frame is ingeniously contrived to secure strength with little weight. Near the center is the manhole, around which is a stout rim of hard wood, nearly circular in form, and about 2 inches high. This rim is supported on the forward and after side by a strongly arched beam of hard wood, 1½ to 2 inches thick in the middle, tapering towards the ends, which are skillfully mortised into the gunwale on each side. From the manhole rim a ridge piece extends to the bow and another to the stern, this being nearly round and about three-fourths of an inch in diameter. The after ridge piece is supported in the middle—about half way from the manhole to the stern—by beams similar to those under the manhole rim. These ridge pieces support the middle of the deck longitudinally, and

*This kaiak has been presented to the Museum by Wm. Burling, esq., and is marked as a "Boat used by Sitka Indians." This is undoubtedly a mistake, to this extent at least: The Sitka Indians do not build such craft, and the occurrence of a skin boat at Sitka is believed to be purely accidental and unusual. Turner thinks this canoe is a hybrid—an unusual form that has the bow of the Aleutian bidarka and the body of the Kadiak Island kaiak.

give it the requisite elevation or arched shape which has been mentioned. One end of each is mortised into the rim of the manhole.

A single-hole kaiak differing from the above is used along a large extent of Alaskan coast, from St. Michael's southwardly.* This kaiak has the sharp ends characteristic of all the skin-covered boats of this region. The forward end gradually tapers from below, as well as from the sides, and rises in a graceful, easy curve upwards, the bow terminating in a sharp point, above and just back of which is a compressed elevated ridge, perforated by an ellipse-shaped hole that varies in size but is usually about large enough to receive the hand of a man. The use and purpose of this is obvious, since it affords a hand grasp to haul the kaiak out of or into the water.

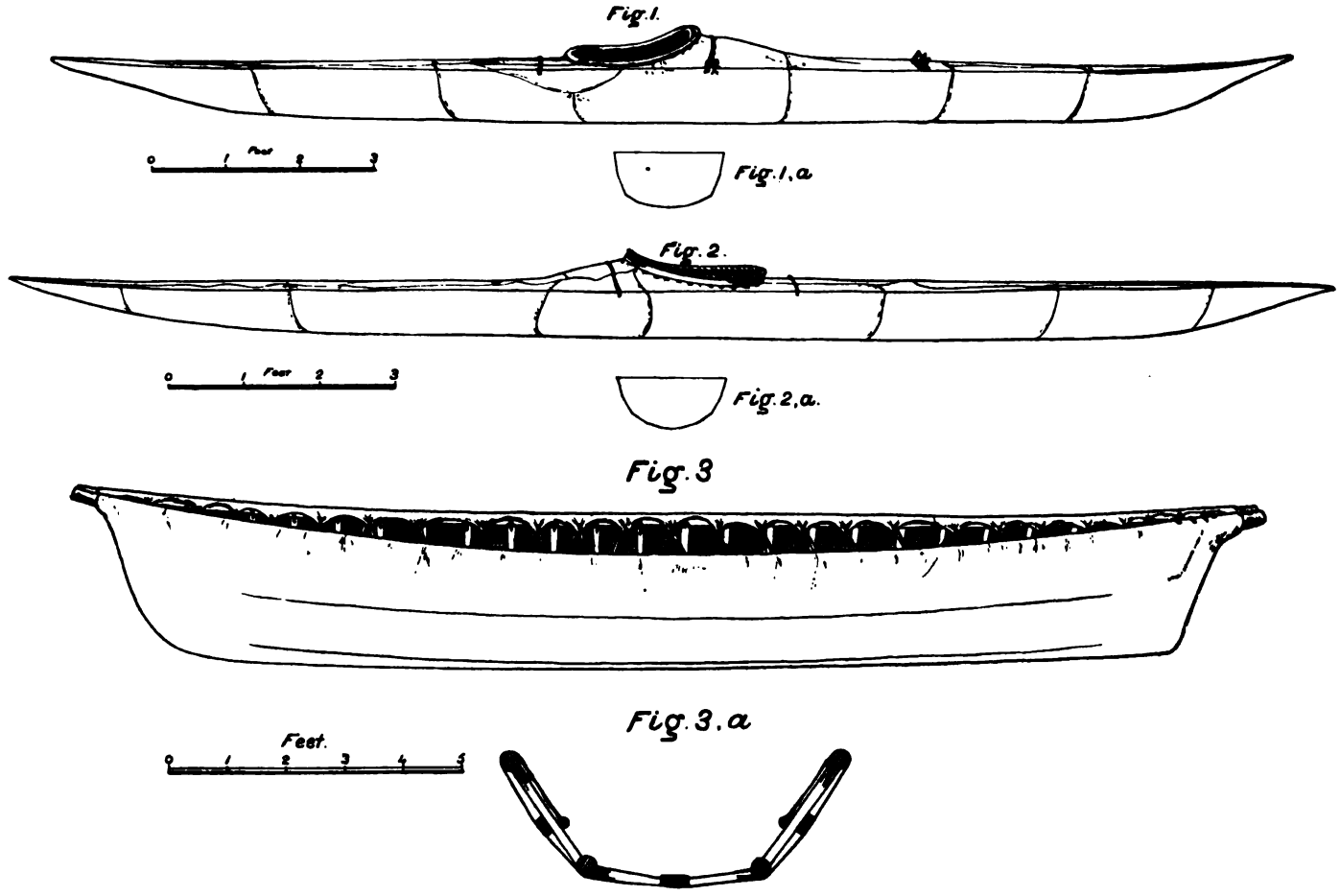
This type of canoe has considerable rise to its bottom, and a deck like that of the kaiak last described. Indeed, the deck rises in quite a sharp ridge, somewhat resembling the top of a pitch-roofed house, although the angle is less. It has the same hogback sheer that has been noticed in the other kaiak. A kaiak of this type (fig. 1, plate IX) in the National Museum is 15 feet long, 2 feet 1 inch wide, and 15 inches deep, exclusive of the manhole. There are several modifications of the type last described, two of which (figs. 2 and 3) are shown on plate IX. These are propelled by a single-bladed paddle, as are all the skin boats of Alaska, excepting those of the Aleuts and those of the most northern section.

14. *The kaiak of Point Barrow.*—The kaiak used by the Innuits at Point Barrow, and thence nearly to Cape Prince of Wales,† is very closely allied in form to that made by the Eskimo of the Hudson Bay region, particularly at Ungava Bay, but it lacks the beautiful sheer and symmetry which characterize the skin kaiaks of the Greenlander.

The frame of the Point Barrow kaiak is made of light pieces of wood, bound together by strips of whalebone or sinew. The keelson rests on the ribs instead of upon the outside skin, as is the common practice in other kaiaks. It has several battens on each side, as in the Aleutian canoe, but the gunwales are wider and not quite so thick, being 3 inches wide by one-half inch thick, while the battens are three-fourths by one-fourth inch. The ribs are half round and of small size, with their ends fastened in to the lower edges of the gunwales, and are lashed to the battens. The manhole rim is supported by beams, as in other kaiaks, but while the after beam is comparatively straight the forward edge of the manhole is elevated considerably, so that, looking at it in profile, it sets at a moderate angle with the axis of the boat. The rim is slightly compressed at the sides, making the shape of the manhole somewhat elliptical. It is held in this position by a wooden standard or button on each side that is made in a peculiar shape, its lower end resting on the top edge of the gunwale, and its upper end so notched that, while one part upholds the manhole rim, the extreme point penetrates through the skin covering and fits snugly to the outside of the rim, thus preventing the latter from springing out of position. The skin deck, instead of passing over the outside of the rim, as it does on many of the kaiaks or bidarkas, goes inside, and, turning over the upper edge, is held in place by a wooden hoop driven tightly over the upper edge of the man-

*Turner says this type is used from St. Michael's southwardly to Kadiak; Dr. Bean recognized it as a form seen at Cook's Inlet, and Petroff (Alaska, 8th vol., 10th Census, page 134) figures it as the kaiak employed by the beluga hunters on the Kuskokvim.

† Turner and Murdoch say this type is used from Kotzebue Sound northward; occasionally it may be seen in Norton Sound. (See figs. 1 and 2, plate X.)



KAIAKS AND OOMIAK.

FIG. 1. Kaiak from Cape Krusenstern.
FIG. 1*a*. Cross section.

FIG. 2. Kaiak from Point Barrow.
FIG. 2*a*. Cross section.

FIG. 3. Alaskan oomiak or bidarrah.
FIG. 3*a*. Cross section of oomiak, showing construction.

hole and firmly secured in place by strips of whalebone or sinew wound around, over and over, as one would sew.

The kaiak of the Point Barrow region has a round bottom and long pointed ends; it is nearly straight on top, except just forward of the manhole where the deck is "crowned" up, forming a sharp ridge that slopes to the level of the forward deck. With this single exception the deck is flat. The following are the dimensions of a kaiak from Point Barrow (fig. 2, plate x):

	Feet.	Inches.
Length over all	18	2
Beam	1	9¼
Depth:		
After side of manhole		10¼
Fore side		14½
Height of manhole rim		1½
Longitudinal diameter of manhole	1	10
Manhole to bow	8	5

Both the single and the double bladed paddle are used on the Point Barrow kaiak, according to Murdoch, who says that the Eskimo prefer the single-bladed paddle when there is no occasion for speed, and they are "jogging along" at an easy rate; but if greater speed is needed they always employ the double paddle. Both are carried.

15. *The oomiak or bidarrah.*—The oomiak (figure 3, plate x), to which the name bidarrah (sometimes written bidara, baidar, or baidarra) has been given by the Russians and largely adopted into the vocabulary of the coast and island natives, is a large open skin boat, now chiefly used for transportation, although it is sometimes employed to capture whales by the Innuits of the north. At Kadiak, according to Petroff, the "bidara" (*angiak*) were formerly used chiefly in time of war and for making long journeys, since they can carry from 30 to 40 people. But at present these boats are nearly all in the hands of the traders. Oars are generally used to propel them, and sometimes they are rigged with masts and sails.* The largest oomiaks on the Alaskan coast are owned and employed for trading purposes, Turner says, and one of these seen by him on the Kuskokvim would carry 45 tons. But those used by the natives, and which are more particularly the subject of consideration here, vary from 18 to 30 feet in length. In regard to the employment of the oomiak in whaling, Scammon writes as follows:

> The Esquimaux whaling boat, although to all appearance simple in its construction, will be found, after careful investigation, to be admirably adapted to the purpose, as well as for all other uses necessity demands. It is not only used to accomplish the more important undertakings, but in it they hunt the walrus, shoot game, and make their long summer voyages about the coast, up the deep bays and long rivers, where they traffic with the interior tribes. When prepared for whaling the boat is cleared of all passengers and useless incumbrances, nothing being allowed but the whaling gear. Eight picked men make the crew. It is said by Captain Norton, who commanded the ship *Citizen*, wrecked in the Arctic several years ago, that the women engage in the chase. The implements are one or more harpoons made of ivory, with a point of slate stone or iron, a boat mast that serves the triple purpose of spreading the sail and furnishing the staff for the harpoon and lance, a large knife, and eight paddles. The knife lashed to the mast constitutes the lance.
>
> The boat being in readiness, the chase begins. As soon as the whale is seen and its course ascertained all get behind it. Not a word is spoken, nor will they take notice of a passing ship or boat

*Alaska, volume 8, Tenth Census, page 141.

when once excited in the chase. All is silent and motionless until the spout is seen, when they instantly paddle toward it. The spouting over, every paddle is raised. Again the spout is seen or heard through the fog, and again they spring to their paddles. In this manner the animal is approached near enough to throw the harpoon, when all shout at the top of their voices. This is said to have the effect of checking the animal's way through the water, thus giving an opportunity to plant the spear in its body with line and buoys attached. The chase continues in this wise until a number of weapons are firmly fixed, causing the animal much effort to get under water, and still more to remain down; so it soon rises again and is attacked with renewed vigor.

It is the established custom with these simple natives that the man who first effectually throws his harpoon takes command of the whole party. Accordingly, as soon as the animal becomes much exhausted, his baidarra is paddled near, and with surprising quickness he cuts a hole in its side sufficiently large to admit the knife and the mast to which it is attached. Then follows a course of cutting and piercing until death ensues, after which the treasure is towed to the beach in front of their huts, where it is divided, each member of the party receiving two "slabs of bone" and a like proportion of the blubber and entrails, the owner of the canoe claiming what remains. (Marine Mammalia of the Pacific Coast, by Charles M. Scammon, pp. 31, 32.)

The oomiak has a flat bottom, tapering to a point at either end, flaring sides, and sharp bow and stern. In shape it closely resembles the American dory, from which it differs in the following particulars: (1) In having less sheer to the top; (2) in having a nearly straight bottom, and (3) in not having the V-shaped stern running down to the bottom, which is a characteristic feature of the dory. But the bidarrah has the buoyancy, the easy lines fore and aft, and the seaworthiness (so far as its form is concerned) that distinguish the dory and have made it famous as a fishing boat.

The covering of the bidarrah varies with the locality. The Aleuts use the skins of the sea lion (*Eumetopias stelleri*), which are unhaired by sweating in a pile, and they are then skillfully sewed together until enough are joined to cover the wood frame of the boat. The northern Innuits make their oomiaks of walrus hides, seal pelts, or white whale skins. The frame is made of wood, usually of pieces of spruce that drift upon the shores, and is deftly lashed together with sinews, strips of whalebone, or thongs of seal skin; the material used for fastening the frame varies somewhat with the locality, and always depends upon the possibility of obtaining that which can be adapted to this purpose.

The number of pieces in a frame may vary, but generally the frame of an Innuit oomiak is as follows: The keelson runs through the center of the bottom, and to the ends of this are attached the stem and stern post, unless the stick grows to the proper shape to make these from one piece. Two other pieces, which may be called sister keelsons, are fitted with a series of holes on their sides to receive the ends of cross bars or beams of unequal lengths (the largest being in the middle), and these form the sides of the bottom, being bent around the beams and their ends fastened to the keelson at the bow and stern. Upon these side keelsons are stepped upright timbers or ribs, which may extend to the gunwale. Along the sides are one or more horizontal strips, the ends of which are fastened at stem and stern post, while they are lashed to each timber; the thwarts rest upon these battens. On top of the stem and stern post is secured transversely a flat wooden piece, like a piece of board, which is 10 to 12 inches wide and 15 to 24 inches long. The gunwales are now bent around, these resting upon and being secured to the upright frames, while the ends are fastened to the upper side of the flat pieces above mentioned, beyond which they project 6 or 8 inches.

The skin is stretched over the frame while it is moist or "green," and having been

fastened over the gunwales and its edges drawn down with lashings to the battens, is left to dry and shrink until the whole fabric is firmly drawn together and the covering is nearly as rigid as sheet iron.

A model (No. 38882) of a bidarrah used at St. Michael's, Alaska, which is now in the National Museum, has a single mast, which is very ingeniously supported by stays and shrouds of seal skin. On this is set a single square sail of coarse matting, which is fastened to the yard with sinews, while the braces, and all the material which on an ordinary boat would be of rope, are here made of seal or walrus hide. Of course it will be readily understood that a sail can be used on such a boat only when it is going before the wind. At other times it is propelled by oars or paddles.

The following are the dimensions of a bidarrah of the type represented by the above-mentioned model:

	Feet.	Inches.
Length over all	23	0
Length on bottom	15	0
Beam, extreme	6	9
Width of bottom amidship	3	0
Height amidship	2	10½
Height at bow	3	0
Height at stern	4	9
Length of mast	13	6
Length of yard	12	6
Sail (feet square)	12	0
Oars	10	9
Paddles	6 to 7	3 9

The illustrations of a bidarrah, figs. 3 and 3*a*, plate X, show the form and construction of one of these boats which is slightly smaller than the dimensions given above.

The finest bidarrahs for transportation seen in Alaska by Elliott were those used by the St. Lawrence natives. He says of them:

> These were made out of dressed walrus hides, shaved and pared down by them to the requisite thickness, so that when they were sewed with sinews to the wooden whalebone-lashed frames of such boats they dried into a pale greenish-white prior to oiling, and were even then almost translucent, tough, and strong.
>
> When I stepped for the first time into the baidar of St. Paul Island and went ashore from the *Alexander*, over a heavy sea, safely to the lower bight of Lukannon Bay, my sensations were emphatic disgust; the partially water-softened skin covering would puff up between the wooden ribs and then draw back as the waves rose and fell, so much like an unstable support above the cold green water below that I frankly expressed my surprise at such an outlandish craft. My thoughts quickly turned to a higher appreciation of those hardy navigators who used these vessels in circumpolar seas years ago, and the Russians who, more recently, employed bidarrahs chiefly to explore Alaskan and Kamchatkan *terræ incognitæ*.
>
> Until I saw these bidarrahs of the St. Lawrence natives, in 1874, I was more or less inclined to believe that the tough, thick, and spongy hide of a walrus would be too refractory in dressing for use in covering such light frames, especially those of the bidarka; but the manifest excellence and seaworthiness of those Eskimo boats satisfied me that I was mistaken. I saw, however, abundant evidence of a much greater labor required to tan or pare down this thick cuticle to that thin, dense transparency so marked on their bidarrahs; for the pelt of a hair seal or sea lion does not need any more attention when applied to this service than that of simply unhairing it. This is done by first sweating the

"loughtak" in piles, then rudely but rapidly scraping, with blunt knives or stone fleshers, the hair off in large patches at every stroke; the skin is then air-dried, being stretched on a stout frame, where in the lapse of a few weeks it becomes as rigid as a board. Whenever wanted for use thereafter it is soaked in water until soft or "green" again, then it is sewed with sinews, while in this soft condition, tightly over the slight wooden frame of the bidarka or the heavier frame of the bidarrah. In this manner all boats and lighters at the island are covered. Then they are air-dried thoroughly before oiling, which is done when the skin has become well indurated, so as to bind the ribs and keel* as with an iron plating. The thick, unrefined seal oil keeps the water out from 12 to 20 hours, according to the character of the hides. When, however, the skin covering begins to "bag in" between the ribs of its frame, then it is necessary to haul the bidarrah out and air-dry it again, and then re-oil. If attended to thoroughly and constantly, those skin-covered boats are the best species of lighter which can be used in these waters, for they will stand more thumping and pounding on the rocks and alongside ship than all wooden or even corrugated-iron lighters could endure and remain seaworthy.†

IV.—THE COD AND HALIBUT FLEETS.

16. *The cod vessels.*—The cod-fishing fleet of the Pacific is fully as varied in the characteristics of its vessels as the whaling fleet, and probably more so. A considerable number of the clipper fishing schooners built in New England have been taken to California in past years and utilized for prosecuting the cod fishery of the Pacific. Vessels of this class are not engaged in the cod fishery at present. The cod-fishing vessels now employed are usually of much greater dimensions than those sailing from New England. Large two-masted and three-masted schooners, of types ordinarily employed in the merchant marine, are engaged in the cod fishery. They usually act simply as freighters. In the spring they carry to Alaska the men and material for prosecuting the fishery, and bring back, as occasion requires, the products which are obtained by the fishermen, who have stations on shore and fish in dories at a short distance from the land.

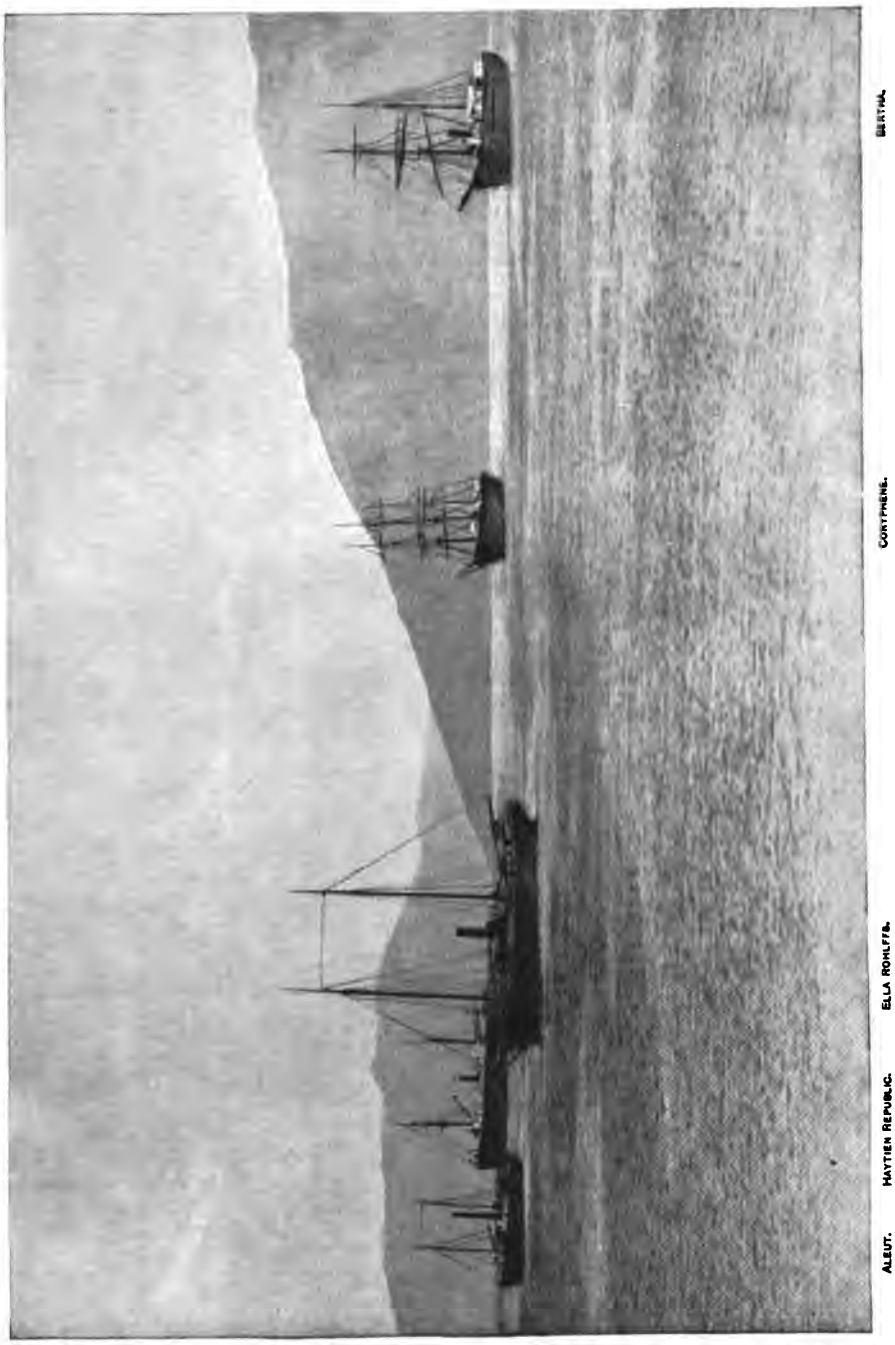
Large schooners and barkentines, and an occasional brig or bark, prosecute the cod fishery in the Okhotsk Sea. In 1888 only two vessels (the *Tremont* and *Jane A. Falkenburg*) were employed in this distant fishery. The barkentine *Tremont* is 328.31 tons. On two occasions she has made the passage from the Okhotsk Sea to San Francisco in 18 and 21 days, respectively. The last-mentioned passage was made in 1888. The barkentine *Jane A. Falkenburg* is another of the Okhotsk Sea fleet. She is 295.10 tons register, 170 feet long, 25 feet beam, and 12 feet deep.

The three-masted schooner *Hera* is probably the largest vessel ever employed in the American cod fishery. She is 369 tons, has two decks, between which are storerooms, galley, and ample accommodations for the crew. She carries a crew of 37 men and 3 boys, has 24 dories and 260 tons of salt when starting on a cod-fishing trip. She has brought in a cargo from the fishing banks of 188,000 fish, equal to 300 tons, or 5,360 quintals of cured cod. Her dimensions are as follows: Length between uprights, 132 feet; beam, 29 feet; depth of hold, 12 feet.

The schooner *John Hancock*, for many years employed in the cod fishery (but which was engaged in the coasting trade in 1888), was formerly a naval steamer. She was Commodore Perry's flagship in 1856, when he visited Japan.

*The use of the word "keel," quoted in this connection, is not strictly correct, since neither the bidarka nor the bidarrah has a keel. Probably the writer had in mind the inside longitudinal frame or keelson.

†"Our Arctic Province," pages 453, 454.



ALASKAN SALMON FLEET AT UYAK BAY.

Some of the vessels are apparently constructed in a manner that makes them unsafe and unsuited to the business in which they are employed.

According to Lieut. Commander Tanner, the *Arago* "is greatly inferior in type to the poorer class of offshore fishing vessels on the Eastern coast, and would not command a crew from Gloucester or Portland. She is 30 years old, and was built at Goose Bay, California. The floor timbers used in her construction were taken from an English bark which was wrecked at that place."*

The typical dory is extensively and almost universally employed in the cod fishery both in Alaskan waters and the Okhotsk Sea. The dories used there are generally built on the Pacific coast, though in some instances they have been imported from the East. As a rule, what are termed "single dories," with a length of about 13 feet on the bottom, are most in favor, one man going in each boat.

On pages 45 and 46 more detailed mention is made of the dories built on the Pacific coast.

17. *The halibut vessels.*—The vessels employed in the Pacific fresh and salt halibut industry (recently conducted to some extent from ports on Puget Sound) are nearly all Eastern-built clipper schooners, that sailed from New England ports to prosecute this fishery, which is a new enterprise in this region. One steam schooner, called the *George H. Chance*, of Yaquina, Oregon, has entered into this fishery, marketing her catch at Portland, which is her fishing port. The vessels sailing from Puget Sound vary from about 60 tons to more than 100 tons, the largest being the *Mollie Adams*, of Gloucester, Massachusetts, and one of the finest of the New England fleet which rounded Cape Horn in the winter of 1887–88.†

V.—SALMON VESSELS AND BOATS.

18. *The salmon fleet of Alaska.*—The salmon fishery in Alaska necessitates the employment of vessels for transporting the supplies and equipments to the stations on the coast, in freighting products to San Francisco or other markets, and in supplying the canneries with fish from points within easy reach. The fleet is composed of vessels of almost every kind, from small sailing schooners to large sea-going steamers. In 1889 the sailing vessels consisted of schooners ranging from 50 or 80 tons to a five-masted vessel of more than 800 tons; besides these there were brigs, barks, and ships of varying dimensions. The steam vessels are mostly small schooners ranging from less than 16 to upwards of 90 tons, used chiefly for transporting salmon to the canneries, from distances varying from 10 or 12 to perhaps 19 miles. Several steamers, however, of considerable size are used as transports or freighters, one of these being the *Haytien Republic*, a first-class ocean-going propeller of 779.53 tons. See plate XI.

* Vol. VIII, Bulletin U. S. Fish Commission, page 22.

† The *Mollie Adams* engaged in pelagic fur sealing a portion of the seasons of 1888 and 1889.

The following is a list of the vessels, their tonnage, etc., which constituted the fleet engaged in the Alaskan salmon fishery in 1889:

Name.	Rig.	Net tonnage.	Name.	Rig.	Net tonnage.
Afognak	Steamer	37.69	C. C. Funk	Barkentine	512.58
Aleut	do	37.68	Ella	do	248.71
Al-Ki	do	72.03	Katie Flickinger	do	448.84
Bertha	do	269.71	Mary Winkelman	do	496.21
Cosmopolis	do	267.23	Modoc	do	429.78
Ella Rohlffs	do	36.64	Portland	do	668.96
Elsie	do	37.69	Quickstep	do	402.21
Farallone	do	286.41	Retriever	do	520.33
Francis Cutting	do	59.79	Courtney Ford	Brig	381.06
Gertie Storey	do	36.69	Adelaide	Schooner	123.57
Hattie Gage	do	42.56	Antelope	do	117.79
Haytien Republic	do	779.53	Cassie Haywards	do	188.02
Jennie	do	50.75	Corona	do	374.65
Karluk	do	220.93	Francis Alice	do	125.26
Kodiak	do	97.75	F. S. Redfield	do	445.85
Salmon	do	35.08	Gem	do	114.47
Signal	do	392.44	Helen N. Kimball	do	182.65
Wm. Seward	do	15.63	Hera	do	369.47
Margaret	Ship	1,160.78	Ida Schnauer	do	204.60
Oneida	do	1,074.26	Jennie Stella	do	278.09
Alden Bessie	Bark	812.55	J. Eppinger	do	107.18
Corea	do	564.62	John G. North	do	320.11
Coryphene	do	771.01	Laura Madsen	do	328.52
Electra	do	939.90	Louis	do	819.80
Elsinore	do	658.03	Nicoline	do	65.50
Hope	do	758.76	Norway	do	183.01
Jas. A. Borland	do	636.69	Novelty	do	584.20
Lizzie Williams	do	790.50	Ocean Bird	do	85.29
Nicolas Thayer	do	555.41	Sadie F. Caller	do	393.25
Sonoma	do	997.67	Vesta	do	271.59
Wildwood	do	1,056.09	Viking	do	139.52
Will W. Case	do	554.61	William Renton	do	424.91

NOTE.—In addition to the foregoing, the following vessels, which were engaged in the cod and whale fisheries, were also employed during a portion of the year in connection with the salmon-canning industry: The steamer *Jeanie* (862.95 tons), the barkentine *Jane A. Falkenburg* (295.10 tons), and the schooners *Czar* (137.13 tons) and *Dashing Wave* (141.46 tons).

As will be seen by the foregoing list, the Alaskan salmon fleet is very heterogeneous in its character, and, since many of the vessels are chartered simply for the occasion, there is liable to be a very material change in the fleet from year to year. With few exceptions the only vessels which may be considered typical fishing craft, and representative of the salmon fishery, are the steam schooners.

19. *Vessels of Puget Sound, and of the Sacramento, Columbia, and other rivers.*—In discussing the vessels employed in the salmon fisheries of the Pacific, mention should be made of the steamer *Thistle*, that plies between Ellensburg, Oregon, and San Francisco, since her business is connected with the prosecution of the salmon-canning industry on Rogue River. This vessel, built at Benicia, California, in 1887, is of moderate dimensions, being only 32.58 tons; length, 70.5 feet; breadth, 18 feet; depth, 9.5 feet; nominal horse-power, 20; indicated-horse power, 80. Her special peculiarity is that she has a screw propeller at both the bow and stern, attached to the same shaft, which runs the entire length of the vessel. The object of this is to prevent the "racing" of the screw in the heavy swells of the Pacific, and particularly when she is crossing the bar at the entrance to Rogue River. It is evident that by such an arrangement the screw at one end will always be immersed and have a good hold on the water. This vessel is used in carrying the products of the cannery at Ellensburg, on the Rogue River, to San Francisco, and bringing thence supplies and equipment for the fishery and the town that has grown up in connection with the canning of salmon on the river.

A considerable number of steamers are used in the salmon industry on the Columbia River and other rivers where the fishery is prosecuted, as well as on Puget Sound;

as a rule they are steam tugs of the pattern ordinarily employed in towing merchant vessels, a business in which many of them engage during the portion of the year when the salmon fishery is not active. A number of small sailing vessels are employed on the Sacramento River in transporting fishery products during the salmon season. They are not, in any sense, typical fishing vessels, though finding incidental employment in the fisheries for short periods.

20. *Steam fishing schooners.**—The peculiarities of climate, winds, and topography on the west coast, and particularly in Alaska, as well as special requirements of certain fisheries, render the employment of small steam fishing vessels necessary, and in some cases imperative. The prevalence of dense fogs in Alaskan waters throughout the fishing season and the vacillating character of the winds render navigation by sailing vessels among the numerous islands and ledges always uncertain and frequently hazardous. This, together with the fact that it is often necessary for salmon canneries to draw their supplies of fish from localities more or less remote, makes necessary the use of small auxiliary steam schooners for bringing the catch to the points where the canneries are located. The elimination of any uncertainty in making passages with the perishable cargoes of freshly caught fish is the all-important matter, for they must reach their destination in good condition or be thrown away. The vessels performing this work must be able to make their way through the intricate channels quite regardless of fogs, headwinds, or calms.

Small auxiliary steam schooners have come into use and special favor for this work. These vessels range from 16 to nearly 100 tons, net register (see plate XI). They vary somewhat in form and slightly in details, but nevertheless are sufficiently alike to be classed as one type. The typical steam fishing schooner of the Pacific coast has about the same relative dimensions of hull as the clipper fishing schooner of New England (of the period between 1870 and 1885), which it somewhat resembles in form. Vessels of this class are, as a rule, very stoutly built and are fitted to stand rough weather. They have the reputation of being seaworthy, but owing to their small size and cramped quarters are rather uncomfortable at sea in a gale. They are provided with sufficient power to go about 6 knots an hour under steam alone.

The following are the most noticeable features of one of these schooners, which is of medium size and is a fair representative of the type. She is a carvel-built, keel craft, provided with screw propeller and auxiliary steam power. Her bow is not very sharp and is somewhat flaring above water; the stem has a moderate rake, is slightly recurved, with a small head; there is a medium rise to the floor; a rather long clean run, broad, elliptical stern; heavy quarters, and not very much overhang. She has an ordinary amount of sheer and considerable freeboard in ballast trim. The deck houses extend from near the taffrail to within 10 or 12 feet of the foremast, with a narrow runway on each side. The pilot house is at the forward end, while the after part of the deck house is essentially a cabin trunk. A short distance abaft the after end of the cabin is the galley in which the cooking is done. The houses thus occupy a large part of the deck. They are strongly built and provided with stout shutters to close the windows in rough weather. Extending forward from the stern about 15 feet is a quarter-

*The ketch rig, such as has been adopted by builders of steam fishing vessels in Europe, is doubtless much better adapted to small auxiliary steam vessels than the schooner rig. In a paper recently published, entitled "Suggestions for Improvements in Vessels Employed in the Market Fishery, with Notes on British Fishing Steamers, etc.," I have produced plans of British fishing steamers which have a rig specially well adapted to the needs of the Pacific coast.

deck, some 18 inches to 2 feet above the main deck, with a corresponding height to the quarter rail. The bulwarks on the main deck are about 2½ feet high.

The rig is that of a two-masted schooner, with short bowsprit; masts, including short-pole topmasts, nearly as long as on a sailing vessel of the same size. The mainmast stands somewhat further aft than it would be placed on a sailing schooner, and the foremast is farther forward. The mainsail is not so wide in proportion, particularly on the boom, as it would be on a sailing vessel. The foresail is also narrow, since the smokestack stands about 10 feet forward of the mainmast. The following are the principal dimensions, etc.:

Length between perpendiculars	feet	77
Beam	do	20
Depth of hold	do	8
Gross tonnage	tons	65.73
Net tonnage	do	37.69
Nominal horse-power		40
Indicated horse-power		80

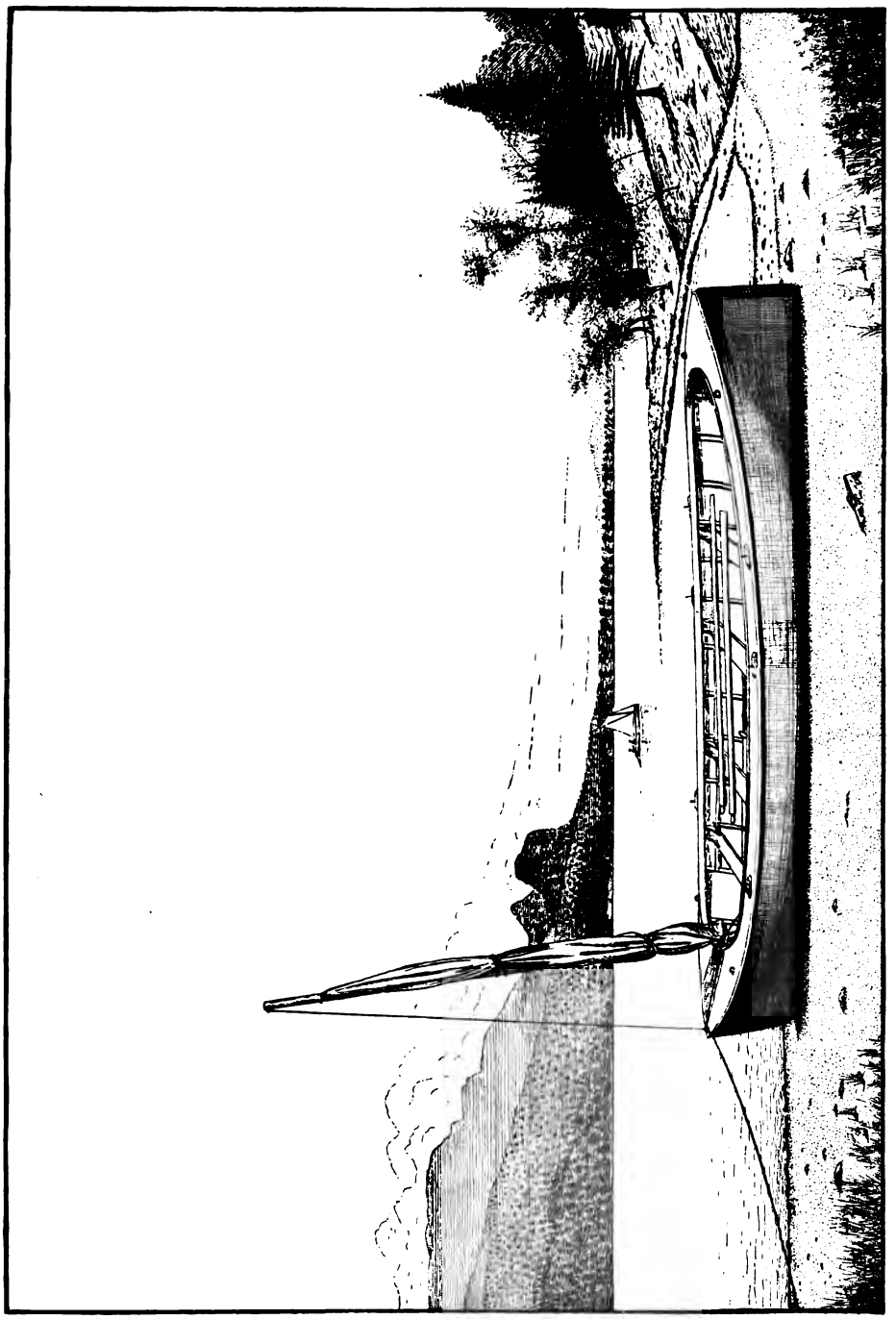
This vessel cost $14,000. She carried, in 1889, a crew of 7 men.

The steam schooner, *George H. Chance*, of Yaquina, Oregon, which was employed in 1888–89 in the market fishery, chiefly for halibut, is similar in type to those employed in the salmon fishery, though somewhat larger. Her dimensions are as follows:

Length between uprights	feet	81½
Beam	do	20 5/12
Depth of hold	do	8½
Gross tonnage	tons	106.40
Net tonnage	do	71.17
Nominal horse-power (estimated)		75

21. *The salmon gill-net boat.*—The boat used in the river and coast gill-net salmon fishery of the Pacific is a distinct type, and differs from any other small craft employed in the fisheries of the United States. It is found in the greatest numbers on the Columbia River, as might naturally be supposed, but it is distributed along the whole coast line of the United States from the lower counties of California to Alaska. This type is also used to some extent in the shore market fisheries, which are not particularly related to the salmon fishery. The first boat of this kind ever used on the Columbia River was built by J. J. Griffin, of San Francisco, in 1869, for George and Robert Hume. This boat was still in use in 1880, and may yet be doing good service. At first the ordinary length was 22 or 23 feet, and usually they were entirely open. Later, boats of 25 and 26 feet in length were built, but they were found to be rather unwieldy for two men to manage, and at present the majority do not exceed 24 feet in length, but as a rule there is now a washboard on each side and a short section of deck at each end. According to Mr. Wilcox, the boats now range from 23 to 28 feet long, 6 or 8 feet wide, and from 24 to 30 inches deep, and cost when rigged for use from $300 to $400. On the Sacramento River the length varies from 15 to 25 feet.

The first boat of this type used on the Sacramento was built by Mr. Griffin for a fisherman nicknamed "Greek Joe," its keel being laid on May 2, 1868. Before that time Whitehall boats and skiffs were employed in the salmon fishery, but were not so well adapted to it as the type under consideration. A well-built salmon boat will last, with occasional repairs, from 14 to 15 years.



COLUMBIA RIVER SALMON BOAT.

About 1872 an undecked salmon boat could be built in San Francisco for $220, but in 1880 the washboard had been added, with the small deck spaces at the ends, and the price had increased to $240 per boat. Many of these boats are built at San Francisco, but a large number are also constructed on the Columbia River, in some cases the owners of canneries having boats made at their own establishments. With few exceptions the boats are owned by the canners and rented to the fishermen. Each boat is provided with a single gill net (that costs about $350 at present) and has a crew of two men.

Ordinarily a salmon boat has a single spritsail, the mast stepping in the forward thwart and being adjustable so that it can be removed at will. Occasionally a jib is carried. On the Sacramento and San Joaquin Rivers a single leg-of-mutton-sail rig is in favor. Spritsails are also used. In strong winds the latter is reefed by taking out the sprit and fastening the peak to the mast. Often when the men are engaged in drift fishing they are compelled to remain away from home for more than a day. Under such circumstances it is common for them, after the nets are hauled, to anchor their boats near the shore or bars of the rivers, out of the way of passing steamers. They then rig up a temporary tent of the sail, using the mast for a ridgepole to spread the canvas over, the after end of the mast resting upon the rudder, which is put up for a support. The men thus lie down for sleep, and this is as frequently done in the daytime as at night, since it often happens that the men are out all night drifting with their nets. Each boat is provided with a small oil stove and an assortment of canned food, which is warmed up, and the meals are thus prepared on board. This applies more particularly to the Columbia River.

The following is a description of a typical Columbia River salmon boat (see plate XII): It is an open, carvel-built, centerboard craft, sharp forward and aft, the ends being shaped nearly alike, moderately concave at and below the water line, and with rather full convex lines above water. It has a long, low floor, round bilge, and flares slightly at the top. It has a very shallow keel, and has little or no rake to the stem and stern post, both of which are straight, with the exception of the rounded fore foot. It is decked for 2 or 3 feet at each end, and has washboards extending along both sides. A coaming 2 or 3 inches high runs around on the inner edge of the washboards and the decked spaces of the bow and stern, making the open part of the boat of an oval form. It has four thwarts, and there are three rowlocks (each with a single thole-pin) on each side. A single mast, upon which is set a spritsail,* is stepped well forward. Oars are carried and used when there is no wind. The dimensions of this boat, which is a trifle larger than the average, are as follows:

Length over all	feet	25½
Beam	do	6½
Depth	do	2
Height amidships, gunwale to bottom of keel	do	2½
Height at ends	do	3
Length of mast	do	16½
Length of oars	do	12
Cost, ready for use		$400
Number of men in crew		2

* Alexander says that the retail price in San Francisco for the cotton drilling used for sails on these boats is 11 cents per yard, and the cost of a sail complete is about $10, half of which is the value of the material—cloth, bolt rope, sheet, grommets, etc.—an equal amount being generally paid for the labor of construction. It is estimated that fully half of the drilling sold at San Francisco for boat sails is used on the salmon boats of the Columbia and Sacramento Rivers.

22. *Salmon seine boats and scows.*—The typical seine boat of the Columbia River and Puget Sound (which is employed for operating drag seines on the Columbia and purse seines in the deep, swift waters of Puget Sound) is a craft of the sharpy pattern. It is an open, flat-bottomed boat, with moderate sheer, sharp bow, wide, square stern, and a good deal of camber to the bottom, particularly in the after section, where it curves up sharply. Boats of this type are roughly and heavily built, the main object being, apparently, to get a craft that will stand a good deal of rough usage, that will float on a light draft, that will easily support the seine on the stern, and which is otherwise well adapted to the fishery.

Writing of the Puget Sound fisheries, Captain Tanner says:

> The boats used in the salmon fishery are about 25 feet long and 7 feet wide, the greatest width being at the stern, which is square. The bottom is flat, but turns up slightly at the stern. These boats have three thwarts adapted for two men rowing at each. About 8 feet of the after part of the boat is decked over and upon this deck the seine is stowed. The method of stowing and throwing the seine differs somewhat from that followed in the mackerel fishery. The salmon seine being thrown over the stern of the boat, it has to be stowed fore and aft instead of athwartship. The corks are placed on the port side, the twine on the starboard side. The twine is thrown in a heap, not arranged neatly in "flakes" and "bits" as upon a mackerel boat, because the man that throws it is not particular to have it clear the stern so as not to retard the speed of the boat in going around a school. The result is that the oarsmen have an extra amount of work to perform.*

On Puget Sound large, clumsy, square-ended scows are used with the seine boats for operating the purse seines, and these, as well as the boats, are often, if not generally, towed to the fishing grounds by steam tugs. Captain Tanner remarks:

> The scow, upon which most of the work is done, and which is considered indispensable in setting the seine, is 20 feet long by 8 wide, and at each end of it is an iron winch. These winches are used for the pursing up, the seine being pursed from the scow. There is a wooden purse davit which is stepped into the side of the scow and to which are attached two 3-inch wooden blocks, the purse line leading from them to the winches at either end. Eleven to fourteen men are required to set the seine, six at the oars, two at the seine, and two on the scow. Of those at the seine, one throws the corks, the other the twine. The cost of a salmon seine boat and scow is from $1,200 to $1,300.

Occasionally the gill-net salmon boats are used for shooting seines. But this is most common in the small rivers where comparatively short nets are operated. As a rule these boats can not be profitably employed for seining on the Columbia River, since their draft is too great for working satisfactorily on the shallow bars of this river, where the seines are commonly landed, and also because, being sharp aft, they can not so well support a seine as the broad-sterned, shallow sharpy.

VI.—THE MARKET FLEET.

23. *General statement.*—The market fishing fleet of the Pacific coast is composed almost wholly of craft of less than 5 tons, many of which are small open boats, only suitable for fishing near the shore, within easy reach of a harbor or land. There is a very considerable variety of boats employed in supplying the markets of the coast, but generally the fleets are composed largely of two types: the felucca, used most extensively at San Francisco and along the California coast, and the salmon boat, which is found in greater or less numbers all the way from San Diego to Puget Sound. Besides

*Explorations of the fishing grounds of Alaska, Washington Territory, and Oregon during 1888 by the U. S. Fish Commission steamer *Albatross*, pp. 55–56.

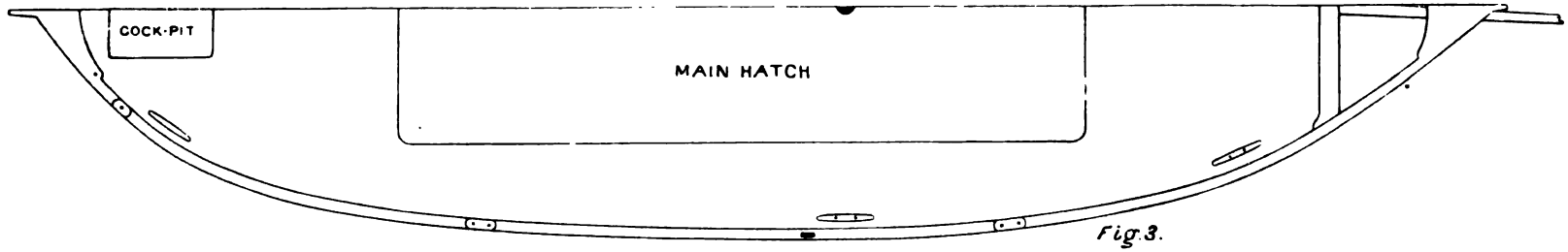


Fig. 3.

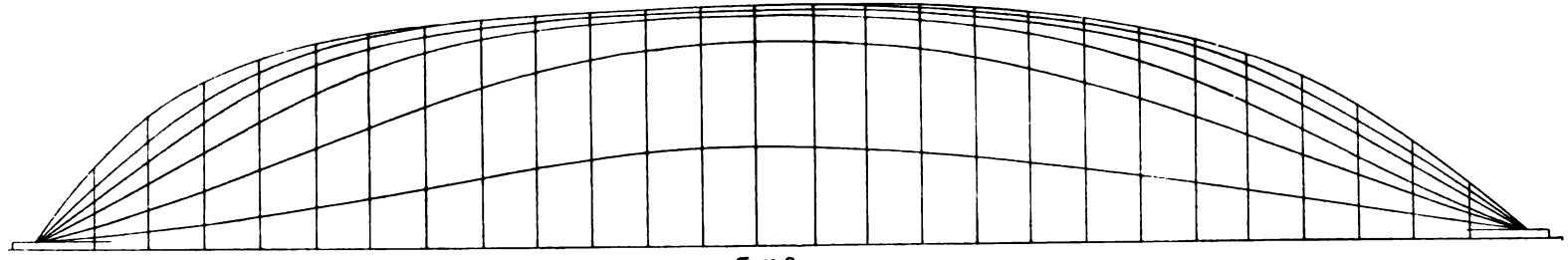
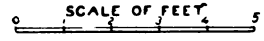


Fig 2



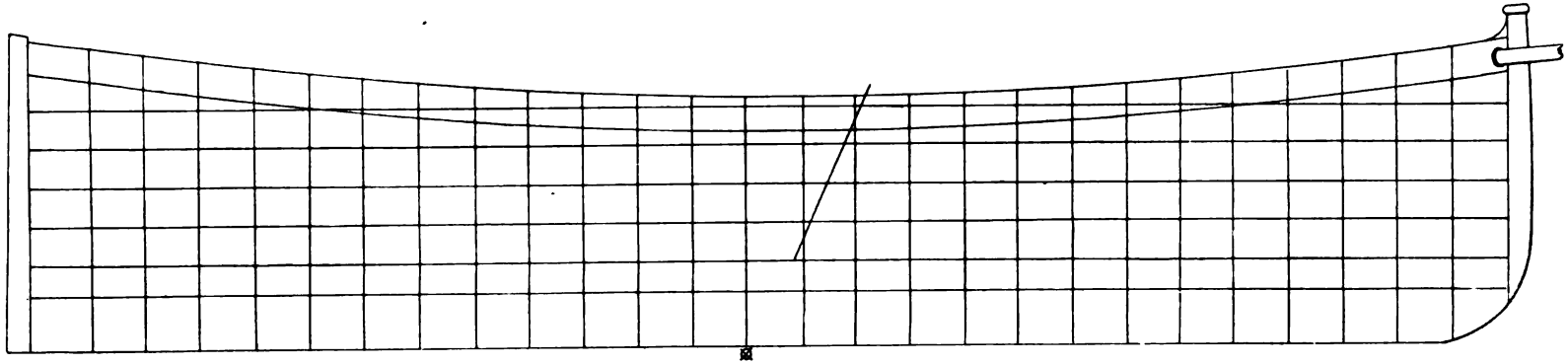


Fig 1.

SAN FRANCISCO FISHING FELUCCA

FIG. 1. Sheer plan.

FIG. 2. Half-breadth plan.

FIG. 3. Half-deck plan.

these there are catboats, sloops, sharpies, and dugouts, the latter being used by the Makah Indians about Cape Flattery and in the waters of Puget Sound.

The steam-tug *U. S. Grant*, of San Francisco, engages in fishing for market with a paranzella, and often tows the fishing feluccas to port during calm weather. She is 17.84 tons net register. The San Francisco Call of April 4, 1887, says of this vessel:

> She was built at the Portrero for the firm about two years ago, and is 65 feet long, 17 feet beam, and 7 feet deep. She is the only vessel of her kind in existence. She resembles a tugboat a good deal in build, for her deck is fitted with a pilot house and engine cabin, and she has the general shape of a tug, but there the similarities end. She was built especially for the fishing business, and below the deck forward are a series of bunkers to contain the fish that are caught. Abaft the bunkers is the pilot house, and adjoining this is the engine and boiler room. The engine is a compound one. * * * Abaft the engine room and below the deck is a small cabin for the use of the fishermen.

24. *The fishing felucca.*—Among the boats employed in the market fishery of the Pacific Coast States the lateen-rigged felucca takes precedence, and is especially in favor at San Francisco, where it is the type chiefly used, while it is found in many other places along the coast of California.

The felucca of the Pacific coast is distinctively European in type; it differs from any other fishing boat used in the United States and resembles the small craft of Italy. The facts that the boats of this class are mostly built by an Italian at San Francisco and that they are manned almost wholly by natives of Southern Europe (Italians, Portuguese, and Greeks), make it easy to understand how this form of fishing craft has peculiarities that characterize the boats of the Mediterranean. There are slight variations in boats of this type, as may be found in all other kinds of fishing craft, but these are of minor importance, and with few exceptions the feluccas resemble each other so closely that none but an expert could tell one boat from another except by the difference in size. Hall* claims that "the model is the nearest approach to a Norwegian pilot boat of anything built in America for practical use." There is, nevertheless, comparatively little resemblance between a Norwegian pilot boat and the market felucca of California. The very hollow floor, great depth, curved and strongly raking stem and stern post, which are noticeable characteristics of the Norwegian vessel, are not seen in the California felucca.

The size of the feluccas ranges from about 20 to 36 feet in length, though the greater number that fish outside of the Golden Gate are upwards of 28 feet long. These boats have the reputation of being excellent sailers and of having a large amount of sail-carrying power. It is said that the fishermen who go on them take great risks in the matter of carrying a heavy press of sail in strong winds. A writer in the San Francisco Bulletin, in 1875, discussing the fishermen and fishing boats of that port, says: "The men are very reckless, and their lateen sails are often seen beating against the wind when our pleasure yachts are glad to find a harbor." It has been claimed that with 800 to 1,500 pounds of stone ballast in the hold these feluccas will rise lightly over any wave, "and are fast and seaworthy." It is a matter of record that only one has been lost from the San Francisco fleet. This immunity from disaster may, however, be chiefly due to good seamanship.

A marked peculiarity, and one which characterizes nearly all of the Mediterranean

* Henry Hall, author of the "Report on the Ship-Building Industry of the United States," published in volume VIII, Report of the Tenth Census of the United States.

boats, is the strong "crowning" or upward curve of the deck in the center, the middle line of the deck being, in some cases, nearly as high as the rails at the side.

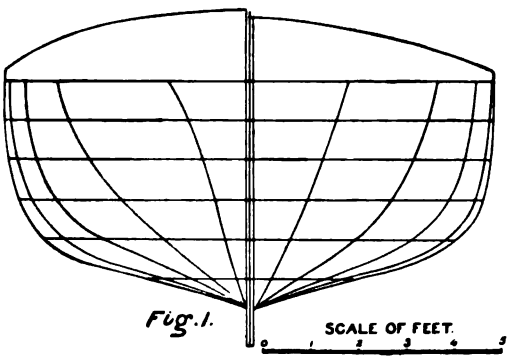
Generally, these boats have a long, large hatch, extending about half the length of the deck, fore and aft, and covered by four or five large sliding hatch covers placed athwartships. The object of this is to have free access to the hold for the storage of fish and apparatus, while it is important to have the hatch coverings to keep water from going into the hold, and also to protect the catch from the sun's rays, since no ice is used, or other specially effective means to prevent deterioration of the fish before they are marketed. As a rule the fish taken are thrown into the hold, but if any are left on deck exposed to the air they are covered by wet sacking to protect them from injury by the sun. These boats are tight-bottomed craft, and have no well or live-box for keeping the catch alive.

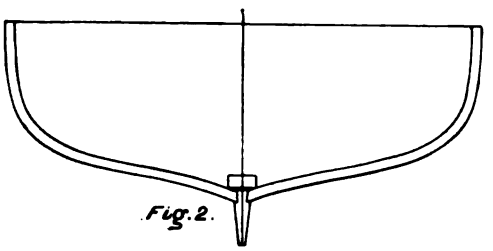
Although these feluccas depend chiefly upon sails for progression, they are all provided with oars, and these are used in calm weather. The fishermen claim that the prevalence of calms and the necessity for making their passages at such times by the use of oars is the reason why they do not use larger boats. It seems not to have occurred to them to build wells in their boats wherein their catch could be kept alive, or to employ small steamers, and, though their attention has been called to this matter by the U. S. Fish Commission, it is possible that their conservatism may prevent them for some time from adopting any innovations of this kind. Boats of this type have frames of Eastern oak and are planked with Oregon cedar. The bottoms are usually covered with metallic paint, but they are never sheathed with copper. They last in good condition for 12 or 15 years, and some of them much longer.

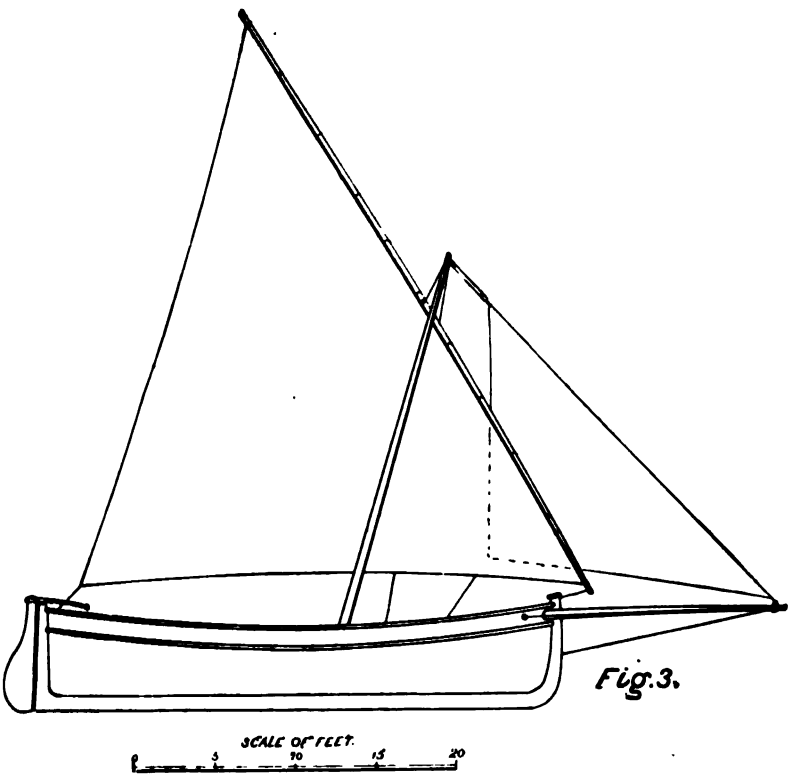
While serving fairly well the purposes of a fishing boat, they are not well adapted for cruises of any considerable length, and have anything but comfortable quarters for the crew of 3 to 6 men, who are frequently compelled to pass several nights away from home, lying in the hold among a confusion of apparatus and other material, which is thrown below under the forward deck.

The rig is that of a single-masted felucca, with a large lateen sail and jib, the latter set upon a bowsprit run out through a hole in the bulwark, usually on the starboard side of the stem. When the yard is upwards of 30 feet in length it is commonly made of two pieces, the abutting ends being joined together or spliced with a rope lashing wound tightly around them.

The following is a description of one of these boats that is employed in the market fishery from San Francisco, and the lines and plans of which appear on plates XIII and XIV: It is a carvel-built, keel craft, with broad beam, moderate depth, and rather strong sheer. It is sharp at both ends, slightly concave at and below the water line, and strongly convex at the rail, the bow and stern being very similar in shape and having considerable flare above water. There is a moderate rise to the floor, a round bilge, and a slight flare above water on the midship section. It has a rather deep keel, and a straight, nearly vertical, sternpost, with rudder hung outside. The stem is straight and almost perpendicular above water, and curved below, with a knob or cap on its top, a characteristic feature of fishing boats of the Mediterranean. It is flush-decked, with a large hatchway amidship, nearly half as long as the boat, and more than half as wide. There is a small cockpit aft for the steersman to sit in; this is generally covered with a hatch when not in use. A bulwark, or waist, 6 or 8 inches high, with a rail at its top, extends around the boat from stem to stern, in the ordinary manner.







SAN FRANCISCO FISHING FELUCCA.

FIG. 1. Body plan. FIG. 2. Midship section below deck, showing construction. FIG. 3. Sail plan.

There are two rowlocks on a side, each fitted with two thole-pins, and one on each side near the stern, each having a single pin. A stout wooden "hawse piece" crosses the bow from side to side and fastens to the rail about 3½ feet abaft the fore side of the stem. There are three cleats on each side of the deck near the waist, for belaying sheets, tacks, etc., one just abaft the hawse piece, another a little forward of amidships, and one abreast of the cockpit. The deck has a strong upward curve, and the "crown" of the hatches is made to correspond with it. The mast is stepped nearly amidships, and has a strong rake forward. It is supported by shrouds, or tackles, on each side. Upon it is hoisted a long slender yard, to which is bent a large triangular lateen sail. The halyard passes over a sheave in the masthead, and is bent to the yard about two-fifths of its length from its forward end, a little forward of the point where it will balance. As ordinarily set, when sailing by the wind or reaching, the forward end of the yard comes down near the stem head, where it is held by a tack-rope, while the foot of the sail is nearly parallel with the deck; but when running before the wind it is common to let the forward end go up, so that the yard is nearly horizontal, the sail being held below simply by the sheet. A jib is carried; it is set flying from a long bowsprit that runs through the bulwarks on the starboard side of the stem, extending outboard about 15 feet, and supported by a bobstay and a shroud on each side. The following are the dimensions of the boat referred to:

	Feet.	Inches.
Length over all, from outside of stem to outside of stern post	32	0
Beam, extreme	10	5
Depth, top of keel to deck, amidships	5	0
Length of hatch	14	9
Width of hatch	5	9
Cockpit, square	2	3
Height of stem above rail		9
Width of stem and stern posts		6
Depth of keel from rabbet		10
Fore side of stem to fore side of mast at deck	14	0
Length of mast above rail	24	0
Length of yard	42	6
Length of bowsprit outside of stem	14	2
Length of tiller	4	0
Width of rudder, extreme	2	0

The dimensions of the sails are as follows:

Mainsail:		
Luff	41	0
Foot	31	6
Leach	36	9
Jib:		
Luff	25	6
Foot	18	0
Leach	16	0

A boat like that described above will carry from 4 to 6 men in a crew, and will cost from $1,000 to $1,200 when ready for sea, including sails, rigging, etc. The ordinary dimensions of these boats, according to Wilcox, are: Length, 23 to 24 feet; beam, 8 to 9 feet; depth of hold, 24 to 28 inches; cost, before rigging, from $240 to $350.

The sails and equipment cost about as much as the hull, so that when a common-sized felucca is ready for sea she will be worth from $480 to $700.*

The following are the dimensions of a boat of this class:

Length	feet..	24
Beam	do...	7½
Depth	do...	2½
Draft above top of keel with 1½ tons cargo	inches..	14
Weight with ballast and outfit	pounds..	2,500

The market fishermen make and repair their boat's sails and do all the painting, rigging, or other work necessary to keep their craft in running order.

25. *San Francisco cat-boats.*—Many of the boats used in the crab fishery of San Francisco Bay are cat-rigged and resemble in general appearance the cat-boats of the Atlantic coast. They are sharp, round-bottomed, square-sterned, keel boats and carry a single boom-and-gaff sail or spritsail. The size varies from 15 to 18 feet in length and 5 to 6 feet beam, and they cost, when rigged, from $150 to $350. The average cost of fishing gear for crabbing amounts to $33.

VII.—OYSTER VESSELS AND BOATS.

26. *Oyster sloops.*—At Shoalwater Bay, Washington, a type of small centerboard sloop is in use in the oyster fishery of that locality. This is employed chiefly in towing the sharpy skiffs, bateaux, or scows to the oyster grounds, where the latter are taken upon the oyster beds and left until the tide ebbs so that the fishermen can go about and pick up oysters, with which the skiffs are loaded. When the tide rises, so that the boats float off the beds, they are taken in tow by the sloops and carried to the place where the oysters are to be landed or put in floating pens or cars to be kept until they are needed for market. These boats vary in size.

One of them may be described as follows: It is a carvel-built centerboard boat, with sharp bow, rounded bilge, moderate rise to floor, easy after section, overhanging counter, and round stern. The stem is nearly straight and vertical above water, and curved below. The boat is flush-decked, with the exception of a large oval cockpit, beginning a short distance forward of amidships and extending near to the rudder head. It is surrounded by a coaming or washboard. She steers with a tiller. The mast stands pretty well forward for a sloop, and she carries a boom-and-gaff mainsail and jib, but has no topmast or light sails. The accompanying sketch, fig. 1, plate XV, shows the boat running up Shoalwater Bay.

27. *Oyster bateaux.*—The "bateaux" used in the oyster fishery at Bay Center, Shoalwater Bay, are wide, flat-bottomed, flatiron-shaped boats. Some of them have a centerboard and carry a single lug-sail. Ordinarily these sail to and from the oyster grounds, but in light winds they are often towed.

The length varies from 24 to 30 feet, beam from 11 to 12 feet.

*Alexander puts the cost, including equipment, much higher; he places the average value of a boat that follows salmon, herring, smelt, trawl and hand line fishing at $375, without fishing gear. "Each boat," he says, "is fitted with 10 salmon gill nets, 3 smelt nets, 5 trammel nets, one 'drag seine' (or paranzella), 8 hand lines, and an average of 35 baskets of trawl lines. The total value of fishing gear per boat is, approximately, $861, and the combined value of boat and apparatus $1,336."

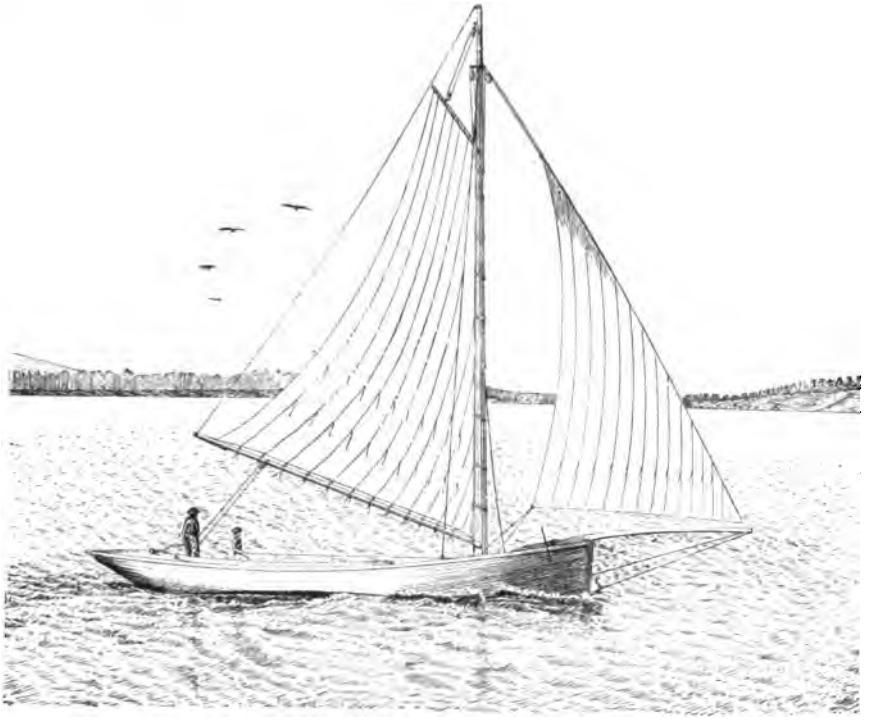


FIG. 1. OYSTER SLOOP, SHOALWATER BAY.

FIG. 2. FISHING JUNK.

28. *Oyster scows.*—In the oyster fisheries of San Francisco Bay flat-bottomed, square-ended scows of varying sizes are employed for tonging and for other purposes. These scows are unpainted, roughly built structures, being wide and shallow. Those used for tonging have a flush deck with a low railing. They are about 18 to 20 feet long and 7 or 8 feet wide. A large open scow, some 16 to 18 feet wide and about 35 feet in length, is used for storage purposes, to receive material, boxes, and the oysters after they have been culled, etc. This is permanently moored near the station on the bay. Alongside of it is a square-ended float or scow upon which the oysters are culled when they are brought in by the fishermen. This has about the same dimensions as one of the tonging scows.

VIII.—DORIES AND SHARPIES.

29. *General statement.*—The fishermen who have been trained on the Atlantic coast have naturally carried with them to the West a preference for certain types of fishing boats which long experience has shown to be specially well adapted to certain work. Thus the dory, which is so extensively employed in the deep-sea fishery of the Atlantic, has been introduced on the Pacific, and its use has increased continuously.

In many cases dories built in the East have been brought across the Continent by rail, but generally it has been found most profitable to build them on the west coast. But while the building of dories might appear to be a simple matter, the attempt to imitate the Atlantic type has usually been a partial failure at the best. Though the west coast dory is generally copied after its Eastern prototype it usually lacks the grace and lightness of the latter, and often has special characteristics of its own. Some of the

FIG. 4. Salmon Dory.

so-called dories used in the salmon fishery of Alaska are hybrids—a type between the dory and the sharpy. They usually have the bow, sheer, and bottom of the typical dory, but differ in having a much wider stern, which, however, is narrower and much deeper than the stern of a sharpy. This modification is caused by the need for additional buoyancy at the stern, but the general form of the dory (which is so excellently adapted to use in rough water and to land upon a beach in a surf) is preserved.

In Alaska, particularly at St. Paul, dories are built by the Indians and Creoles for general use about the harbor and islands. Spruce and cedar are used in their construction. Alexander says they approximate to the shape and general appearance of the New England dory, but are not good copies. But, in view of the fact that white men

who are professional boat-builders often fail to imitate the dory successfully, he thinks the Indian builders of St. Paul have no reason to feel ashamed of their workmanship. The dories vary in size from about 13 feet in length on the bottom (the size used for hand-line cod fishing) to 15 or 16 feet.

In some localities, particularly on the southern coast of California, the typical sharpy or bateau is sometimes used for fishing. Those seen were similar to the small flat-bottomed craft in common use on the Chesapeake and Delaware Bays.

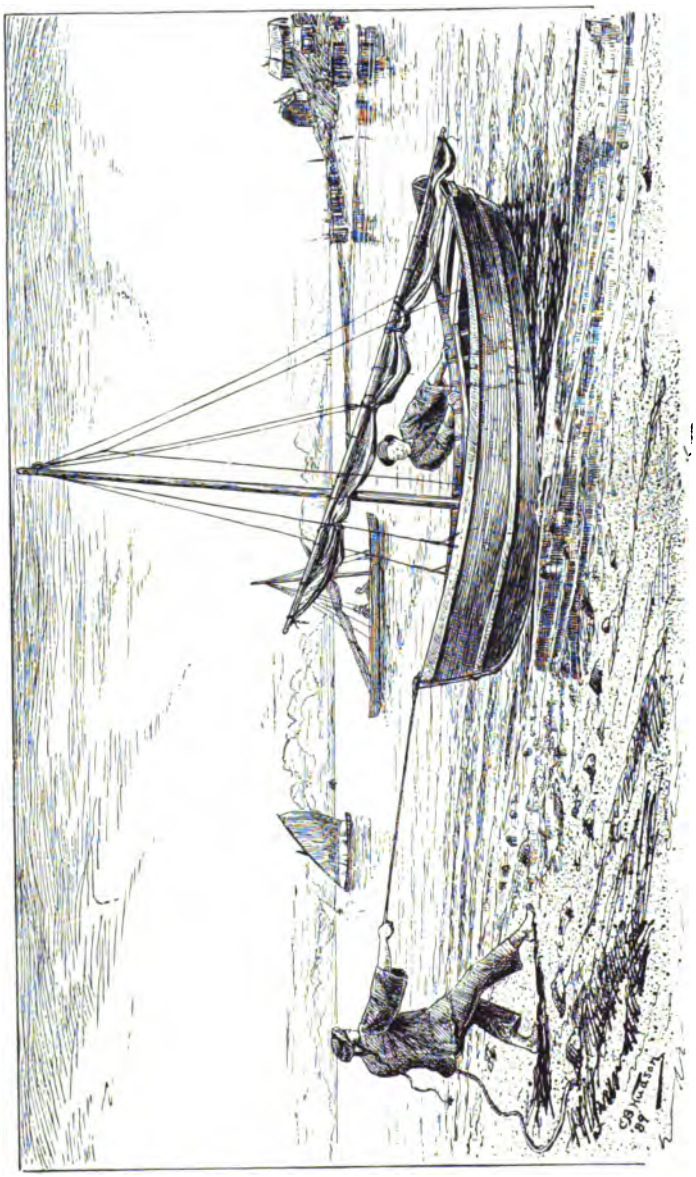
IX.—CHINESE FISHING CRAFT.

The vessels and boats used by the Chinese in the Pacific coast fisheries are distinctive in form and rig, and embrace a number of types having special peculiarities. The junks are the only craft large enough to be registered. These are not, however, documented like ordinary fishing vessels, but are considered alien vessels sailing under a permit from the custom-house. There is quite a fleet of junks from San Diego and and also one sailing from San Francisco.

30. *Chinese fishing junks.*—The junks used by the Chinese fishermen that sail from California, and of which examples may be found at San Diego and San Francisco, are generally above 5 tons, the largest of them being about 15 tons. These junks are built in California and resemble in many particulars craft that are used on the coast of China. One of the largest that sails from San Diego, and which is shown in fig. 2, plate XV, has the following characteristics:

It is a carvel-built keel craft, with strong sheer, raking stem, sharp flaring bow, and rounding bilge. It is practically sharp aft, like an old-style "pinkie," but has a sort of overhanging counter, forming a kind of square stern, which is merely an extension of the bulwarks posteriorly. It has a very wide rudder, which, as is customary on Chinese junks, is so arranged that it can be lifted up when the vessel is in harbor or lowered below the keel when it is sailing. The object of lowering the rudder is that it may prevent the vessel from making too much leeway when sailing by the wind. The rudders of the California junks, however, are perforated with numerous holes, like those on vessels built in China. There is a large hatch on the after part of the deck and another amidships. A rude sort of windlass, which is used for hoisting the anchor and perhaps other apparatus, is located just forward of the mainmast. This junk is lorcha-rigged and carries two masts and two sails. The foremast is stepped close to the stem, its heel resting upon the apron a few feet under deck. It rakes slightly forward. The mainmast is much longer than the foremast. It stands a short distance forward of amidships and has no rake. It is supported by two shrouds on a side, one of these being set up well forward and the other several feet abaft of the mast. Lorcha sails, made of cotton duck, are carried. In the illustration these are shown furled. The foresail tacks down to a bumpkin that extends forward beyond the stem. Each junk is usually provided with one or more flat-bottomed skiffs, like those used in the shrimp fishery at Monterey, which are described in another paragraph.

The junks are roughly and cheaply built; nevertheless, they have the reputation of being pretty good sailers and seem to be safe. They fish chiefly along the coast of southern California, and also on the Mexican coast, and do not return to American



CHINESE SHRIMP BOAT.

ports unless it is absolutely necessary for them to do so in order to market their catch, since it is requisite that they should enter and clear at the custom-house whenever they arrive at San Francisco or San Diego.

The following are the principal dimensions of the one above described:

Length	feet..	54
Beam	do...	12
Depth of hold	do...	4
Tonnage, net	tons..	14.30

31. *Chinese fishing canoe.*—Among the various kinds of boats used by the Chinese fishermen on the coast of California is a type that is practically a long, narrow, flat-bottomed canoe, sharp at both ends, with the bottom pretty wide in the middle and the sides flaring moderately (see plate XVI.) This is used extensively on San Francisco Bay, and is in favor among the Chinese shrimp fishermen, though it is also utilized in other fisheries. It is entirely open, with two thwarts and two large platforms, one of the latter being in each end of the boat, a short distance from the bow and stern, respectively. About one-sixth of the boat's length from each end, and directly opposite the platforms mentioned, are bumpkins, which project from each side a distance of several inches. The bottom is tolerably straight in the middle, but has a good deal of camber at the ends. The boat has a moderate amount of sheer at the top.

This type of boat is propelled by both sail and oars. The mast, on which is set a lateen sail, is stepped about one-third the boat's length from the bow; the sheet of the sail trims to the after bumpkins, and the tack is fastened to the bow. When running before the wind the tack is loosened so that the yard lays at nearly right angles to the mast, the sheet of the sail being taken down amidships. Boats of this class vary from 15 to 20 feet in length, are managed by two or three Chinamen, and are employed in the general coast fisheries of California, though most commonly found in San Francisco Bay. They are constructed in a rough manner, and their cost is comparatively trifling. They are convenient, however, for landing on beaches, or for working in shallow water. They sail well, running free, and are light and buoyant in a sea way. The following are the dimensions of one of them:*

	Feet.	Inches.
Length, over all	20	0
Beam	3	11
Width of bottom amidships	2	4
Depth, amidships	1	7½
Mast, total length	15	0
Yard, length	20	10½

32. *Chinese fishing skiffs.*—The Chinese fishermen on the coast of California, and particularly at Monterey, use a skiff-like boat that appears to combine many of the features of the American fishing dory and the bateau or sharpy skiff, both types of which are employed to a greater or less extent on the Pacific coast. The Chinese boat, however, has certain distinctive features that are not found elsewhere among the small craft employed in the American fisheries. It is a flat-bottomed, sharp-bowed craft, with flaring sides and strong sheer. The forward section has a marked resemblance to the bow of a dory. The bottom near the stern curves up sharply and there is no skag.

*The dimensions, as well as the typical description, are based upon a model obtained by the U. S. Fish Commission, and now in the fishery collection in the National Museum at Washington, D. C.

The width of the stern is intermediate between the dory and sharpy skiff, being much wider than the former and narrower than the latter. The construction of the stern is purely oriental in style, and not only resembles boats of China but is almost exactly like the Japanese *indune*. The planks on each side project several inches abaft the cross-planking of the stern, and over the latter there is sometimes a piece of board laid flat, extending athwartships, its ends passing through the planks on each side just beneath the gunwales.

Ordinarily boats of this type, which are in great favor among the Chinese fishermen, are entirely open, with a short platform at the bow a few inches below the gunwale; a similar platform at the stern, and three narrow thwarts. The mast steps about 8 feet from the stem. The accompanying illustration (plate XVII, shows a fleet of these skiffs that are used by the squid fishermen, lying on the shore near the Chinese fishing camp at Monterey.

These boats are built of redwood by the Chinese. The following are the dimensions of one of them of the average size:

	Feet.	Inches.
Length, over all	20	11
Beam, extreme	5	10
Depth	2	4
Width of stern	3	6

A writer gives the following description, in the American Field, of a type of Chinese fishing boat used on the Pacific coast, a sample of which he saw at a Chinese camp near Point Madison, on Puget Sound:

There was but one boat hauled up on the outer beach, and she was evidently hardly seaworthy. Her appearance was that of a typical Chinese fishing boat; her bottom was flat, sides slightly rounded broad, square stern high out of water, low, narrow, square bow, and strong sheer. She was open, with a broad washboard all around, and a little deck in the bows and at the stern, and was divided into four compartments by water-tight bulkheads. There was no mast, and only six thole pins with double notches to hold the grommets that are shipped over the handle of the long sweeps just above the broad blades that are nailed to them. The sweeps are handled after the fashion of the Venetian gondoliers by the oarsmen who stand on the opposite side of the boat. She was 15 feet long and 4 or 5 feet broad at the stern, the widest part.

SQUID SKIFFS, MONTEREY.

3.—OBSERVATIONS UPON FISHES AND FISH-CULTURE.

Materials of the kind included in this article have heretofore appeared in the report of the Division of Fish-Culture and have been published as a part of the Commissioner's Report. They are derived almost entirely from the reports of the superintendents of the stations and officers in charge of vessels of the Commission, and the language of the authors is preserved as nearly as possible. From the nature of the paper, arranged as it is by species in their zoölogical order, it would be difficult to indicate the authority for each item, but a list of the persons from whom information has been obtained is given below, together with the names of the stations or vessels furnishing the scene of their observations. The notes have been arranged for publication by the editor of the Commission, Dr. Tarleton H. Bean.

LIST OF PERSONS FROM WHOM NOTES HAVE BEEN OBTAINED.

A. C. Adams, schooner *Grampus* and Gloucester, Mass.
C. B. S. Adams, M. D., steamer *Fish Hawk*.
C. G. Atkins, Craigs Brook and Schoodic stations, Me.
H. H. Buck, Green Lake, Me.
Frank N. Clark, Alpena and Northville, Mich.
Richard Dana, Woods Holl, Mass.
Henry Douglass, Sandusky, Ohio.
Vinal N. Edwards, Woods Holl, Mass.
John Gay, Gloucester, N. J.
Rudolph Hessel, Carp Ponds, Washington, D. C.
W. F. Hubbard, Clackamas, Oregon.
Fred Mather, Cold Spring Harbor, N. Y.
John Maxwell, Woods Holl, Mass.
W. F. Page, Neosho, Mo.
Robert Platt, lieutenant U. S. Navy, steamer *Fish Hawk*.
W. de C. Ravenel, Battery station and Havre de Grace, Md.
H. M. Smith, M. D., Washington, D. C.
Livingston Stone, Clackamas, Oregon.
Geo. B. Williams, jr., Baird, Cal.
S. G. Worth, Central station, D. C., and Fort Washington, Md.

Sawfish (*Pristis pectinatus*).

A sawfish, measuring 15 feet 4 inches and weighing about 600 pounds, was taken at San Carlos Bay, Fla., by the steamer *Fish Hawk*, on March 22, 1889. The skin was prepared in a very skillful manner by the surgeon of the vessel, Dr. C. B. S. Adams, and was presented to the U. S. National Museum. A female was also surrounded by the seine, but escaped before the haul was landed. It was supposed that the pair had approached the shore for breeding purposes. The bottom upon which they were found was covered with fine white sand, intermingled sparsely with small shells, chiefly scallops.

Carp (*Cyprinus carpio*).

Spawning was in progress at the Carp Ponds from May 10 to 15, 1889. Mr. Hessel found the roots and even the entire surface of certain water plants covered with eggs. Some injury was caused by cold nights, and the superintendent restocked the ponds artificially with about 2,000,000 eggs on or about May 10. During May the carp grew to a length of 1 to 1½ inches.

Goldfish (*Carassius auratus*).

At the end of May, 1889, the Chinese and Japanese goldfish in the ponds at Washington had reached a length of about 1 inch.

Tench (*Tinca tinca*).

According to observations of Mr. Hessel, adults and young of this fish remain close to the bottom of the pond, both day and night.

Golden Ide (*Idus melanotus*).

Spawning began at the Carp Ponds, April 16, 1889, on a low temperature. Six days of warm weather followed and the eggs hatched on the fifth or sixth day. Early in May Mr. Hessel noticed among the young a school of the rare white variety, which did not mingle with the common yellow or red ones, but kept aloof, even when feeding.

Shad (*Clupea sapidissima*).

In the season of 1889, at Havre de Grace, Mr. Ravenel found that the fry hatched at Battery station seemed stronger and in better general condition than those at the auxiliary station at Havre de Grace. This he attributes to the better lighting of the Battery hatching house.

The variable and low temperature of the water in the early part of the season, (50° on May 4 and not reaching 70° until after May 8) made the first fry weak and unfit for long shipments, the period of incubation being so greatly protracted.

From the 15th to the 27th of May 1,713 gravid females furnished 57,809,000 eggs, an average of about 33,750 each.

On May 16, 1,575,000 eggs were placed on car No. 3 to be hatched en route to Albany, N. Y., for the Hudson River.

The first fish were hatched April 25, with the surface water at a temperature of 60°.

In 1890 the collection of eggs at Battery station, Md., began April 21 and ended May 20. From May 7 to May 20 the work was retarded by heavy rains, followed by muddy water. The temperature of the water varied from 52° to 70°. The number of eggs taken during the season was 32,405,000. The largest take in one day was 3,419,000, on April 24. The eggs were of excellent quality and the fry were remarkably vigorous. The number of females handled was 985, which yielded an average of nearly 33,000. The catch of shad at the head of the bay and in the Susquehanna and Northeast Rivers was very small, probably on account of the May freshet, which shortened the seasons.

On the Delaware eggs were collected from May 12 to May 28 and fry were distributed from May 20 to June 4, 1890.

During the egg-collecting season in the Potomac at Fort Washington, Md., the lowest mean temperature of the water was 52°, the highest 78°. The greatest number of shad eggs taken any one day was on May 6, when 8,368,000 were secured, the mean temperature of the water being 59°. April 24, 6,124,000; temperature, 63°. May 7,

6,311,000; temperature, 61°. With the temperature at 78° the largest yield was only 148,000.

April 29, 1889, Mr. W. A. Wilcox stated that the shad catch of the Sacramento was 56,471 pounds; June 22, 1889, he announced the occurrence of shad in the Columbia River; May 8, 1889, he again mentions shad in the Columbia River.

W. H. Woodcock, January 25, 1889, reported three shad caught in the Stikine River, Alaska, by salmon fishermen during the past season.

April 20, 1889, Prof. Charles H. Gilbert reported that there was no foundation for the statement of the capture of shad in the Colorado River.

In 1890 the collection of eggs for the *Fish Hawk* began April 30 (when 40,000 were obtained) and closed May 23. Nearly 34,000,000 eggs were collected during the season, from which were obtained 20,596,000 fry. Eggs were taken from 691 females, the average being about 49,000 to a female. The greater portion of the eggs were taken in the first half of May. The temperature of the surface water at 8 a. m. varied from 57° on May 1 to 64° on May 15.

At Fort Washington station, in 1890, the usual shad-hatching operations were conducted in April and May. Although shad were abundant in the wide waters and the lower river, they failed to reach the headwaters in sufficient numbers to furnish the usual quantities of eggs, and those that were obtained were secured in small lots. The seine belonging to the station took only 4,606 shad, while the annual average of four seasons preceding was 8,800. The abnormal conditions were expected as a consequence of the unusually open winter. The production of eggs was no earlier, but several schools of fingerling shad were surrounded by the Fish Commission seine and by the seine at Moxley's Point, an occurrence not previously observed by Superintendent Worth since the station was established. Associated with the shad were schools of fingerling herring. The smallest of the shad were only 5 inches long, a size not usually seen in rivers in the spring. Another unusual occurrence was the daily catching of young sturgeon. The whole number of shad eggs collected was 35,202,000. The collecting began April 15 and closed May 17. The greatest number taken in one day was 3,564,000, on May 5, 1890.

H. M. Smith, of the Fisheries Division of the Fish Commission, observed a peculiar habit of the shad in the town of Steuben, Maine. The fish arrive in June and are taken in brush weirs set for herring as late as October. At times they go into Dyers Bay at high tide and remain on the flats when the tide recedes. The fishermen do not think that the shad are stranded, but are inclined to believe that the habit is due to a dislike to return to salt water. It is observed that the fish make holes in the soft mud and sand, in which they remain until the water again covers the flats. From conversations with the fishermen it would appear that during some seasons large numbers of shad are seen at the head of the bay and are easily taken with the hand. The annual number reported to have been thus caught in 1888, 1889, and 1890 was between 150 and 200, although many more could no doubt be secured were the fishermen so disposed. This habit of the shad has not been reported elsewhere in Maine and appears to be unique.

California Salmon (*Oncorhynchus chouicha*).

This salmon came into the McCloud River, at Baird station, Cal., in two runs in 1888, the first beginning August 14 and ending September 24, the second beginning

October 29 and closing December 15. Owing probably to the high temperature of the water, which averaged 55.8° during the first run, the eggs hatched in 36 days. During the second run the temperature of the water averaged 46.8°, and the eggs were 64 days in hatching.

The seine hauls in August averaged from 18 to 20 fish, which were mostly small males. On August 18 a ripe female was taken. This is an unusually early spawning date. Owing to the high temperature the eye-spots appeared in the eggs on the fifteenth day and hatching began on the thirty-sixth day. The shortest incubation period heretofore was 40 days.

The observations of persons living on the McCloud led to the expectation of a large run of salmon at Baird station late in October, and it was determined to continue the taking of eggs during this late run. The salmon arrived late in October and continued to come during November. A large portion of the females caught October 28 were not ready for spawning

In the first run 375 females yielded 1,439,100 eggs, averaging nearly 4,000 each. In the second run 830 females furnished 3,862,000 eggs, an average of nearly 4,700 each.

In 1889, salmon first appeared in McCloud River on August 14, when a ripe female was caught in the trap at Baird station. This was unusually early, and no more were taken until August 27, when very few salmon were in the river. The late run of salmon commenced October 7, and many ascended the river while the racks were removed by a storm. On October 16, when fishing was resumed, 40 salmon, fresh from the sea and none of them ripe, were caught in one haul. On November 18 the run of fish ceased.

Of the salmon taken from the first run 1,129 were males and 382 females, of which 253 were gravid. In the second run 94 males and 170 females were taken; of the females 112 were ripe. The average yield of eggs from each female of the first run was 4,385; of the second run, 5,075; the average from 371 females was 4,600.

At the rack on the Clackamas in July, 1888, thousands of salmon which were prevented from ascending to their spawning grounds remained all summer until the spawning season arrived, the great mass of them always within 30 rods of the rack, which was continually attacked by relays of fish for the purpose of breaking it down.

From 969 females at the Clackamas station were taken about 4,600,000 eggs, an average of nearly 4,750 each.

On August 24, 1888, a number of large males were caught, indicating a run of salmon. This run made its appearance, but was small.

It was expected at Clackamas that the salmon which arrived at the rack in March and April would spawn about the middle of July, as they would have done at the sources of the river naturally; but ripe eggs were not obtained until near the end of August, and Mr. Stone has reached the conclusion that "their eggs will not ripen until about the time for the regular spawning season to begin at that portion of the river where they happen to be at the time."

Mr. Stone also concluded "that the salmon can not deposit their spawn until the temperature of the water where they are has reached the degree of cold natural to the river at the time of the regular spawning season at that point; or, in other words, if the water is not cold enough the salmon can not deposit their spawn. It also appeared that if the salmon are kept too long in water not cold enough for them to spawn in they will die; and if in some exceptional instances loose and apparently ripe eggs are found in them the eggs are worthless." In consequence of this belief it was decided

not to put in the rack at the Clackamas in future until the first run has ascended to their natural spawning grounds.

Early in September, 1888, owing to some peculiarity of the water supply of the Clackamas hatchery, serious injury to the eggs and young fish was observed. Investigation showed that at the time the early eggs were placed in the hatchery Clear Creek was very low, little rain having fallen and the impurities and minute vegetable and animal growth, which had accumulated in the creek during the summer from natural causes and from the deposits of mills up stream, remained in it. It was believed also that the great variation between the temperature of the Clear Creek water during the twenty-four hours, a difference of 10° having been noted, was another important factor in the imperfect development and death of eggs and embryos.

Mr. Stone believed further that many of the eggs taken early in the season were spoiled inside of the fish before they were taken. He thinks that a large percentage of the breeding salmon that were spawned before and perhaps during the first week in September contained these worthless eggs.

The egg-collecting season on the Clackamas River, Oregon, extended from August 28 to November 6 in 1889. The largest number of eggs taken in one day was 208,000, on September 27; the least number was 4,000, on August 29; the daily average of eggs collected was 62,514. The females handled numbered 957; the average number of eggs to each was 4,507. Mr. Hubbard states that more males are taken always than females. He estimated that the fry produced in the hatchery equaled about 85 per cent of the number of eggs introduced into the building.

Mode of capture.—Four traps were built in Clackamas River for catching salmon, one on the rack and three below it on the shallow riffles. These traps were placed at the lower end of a riffle where the water is very swift and the bed of the river has a good deal of fall. They are built of poles or slats in such a way that the water runs into the mouth of the trap with a great deal of force and passes out through the bottom, leaving the fish that come into them on the floor. Wings extend from the mouth of the trap up the river, diverging until at the upper end they are as far apart and take in as much of the river as possible. The fish are driven into these traps by stretching a net across the river some distance above the trap and drawing it down stream, driving the fish before it into the trap. The ripe fish are then taken out and put into pens when ready for spawning, the unripe ones being returned to the river.

Atlantic Salmon (*Salmo salar*).

In 1888 a plant of 20,000 fry, from Cold Spring Harbor, N. Y., was made in the Nissequogue River, Long Island, and this was repeated in 1889. The growth of salmon in this stream is remarkable; a yearling, caught by Mr. L. D. Huntington, May 15, 1889, was 7⅛ inches long and 1½ inches in greatest depth. In 1889 the station received from the hatchery at Orland, Me., 700,000 eggs; of these 25,000 were sent to the Fulton Chain hatchery, New York, and 17,500 to the hatchery of the Bisby Club, in Herkimer County, N. Y. These waters empty into Lake Ontario at Sacketts Harbor. The remaining eggs furnished 20,000 fry for the Nissequogue, as above stated, and 618,188 for tributaries of the Hudson.

On September 19, 1888, Mr. Atkins found, at Craigs Brook, a parr 6½ inches long which gave milt.

The rearing operations at Craigs Brook, Me., during the summer of 1889 were

remarkably successful. Of the yearling Atlantic salmon 89 per cent were saved, and the eggs of this species yielded 83 per cent of fish at the time of distribution. Mr. Atkins believes that the losses of fish were less in the second year than during their first year. The winter losses were small. The rearing troughs, holding about 2,000 fry, are 8 inches deep, 12¾ inches wide, and about 10 feet long.

Fish disease.—At Craigs Brook station, in May, 1890, while the fish were in the yolk stage, they were attacked by a disease previously unknown at Craigs Brook, which during May and June destroyed nearly one-third of the entire stock. It first appeared among the Atlantic salmon, but it was most fatal to landlocked salmon, sälbling, and Swiss lake trout. Some lots of fish were not attacked and some were exterminated by it.

Schoodic Salmon (*Salmo salar*, landlocked).

At the Schoodic station from 457 females the average number of eggs taken was 2,100 each. Three small females yielded 2,300 eggs, an average of 767 each.

Of the 495 males examined, the average weight was 3½ pounds, the heaviest 5½, the lightest 1¾. The average length of males was 19⅛ inches, the longest being 24 and the shortest 15½ inches. 471 females were weighed and measured, the average weight being 3¾ pounds, the heaviest 6¾, the lightest slightly more than 2 pounds. The average length was 19½ inches, the greatest 24 inches, the shortest 16½.

During the egg-taking season (October 24 to November 24, 1888) the temperature of the river water ranged from 49.5° to 34°. The mean temperature for October was 52.5° and for November 42.3°. The mean temperature of the river water in December was 35.3° and in January 34.5°. This comparatively high temperature hastened the development of the eggs, bringing them to the shipping stage unusually early, the shipments beginning January 29, 1889, and continuing until February 5.

At Schoodic station, Maine, the fishing was begun October 25, 1889, and continued until November 24, during which time 871 salmon were handled, including 313 males, 557 females, and 1 of unknown sex. The average yield of 517 females was 2,350 eggs each. The proportion of males was much larger than last year, and the yield of eggs greater. The total weight of eggs was 471 pounds 5 ounces, amounting, after deducting losses, to 1,017,000. The largest fish of the season was a male, measuring 26 inches and weighing 6 pounds. The heaviest female weighed 5½ pounds and measured 23½ inches; and the longest female measured 24 inches and weighed 5 pounds 6 ounces. On liberating the fish at the end of the season almost every female yielded a few eggs. From them 33 pounds, or about 75,000 eggs, were obtained, which hatched as readily as any of the others.

In the operations of Green Lake station it was found that the first salmon in 1889 appeared on the night of October 14. Spawning operations began November 4 and continued until November 15. The number of male salmon handled was 50, and of females 75. The females yielded an average of nearly 4,000 eggs. Mr. Atkins found that the males averaged 22.3 inches in length and about 5 pounds in weight; the females 25.5 inches in length and 7.8 pounds in weight. Of the females, 69 retained all or nearly all of their eggs. The longest and heaviest male measured 31 inches and weighed 13$\frac{5}{16}$ pounds. The heaviest female was 30 inches long and weighed 11$\frac{9}{16}$ pounds. The water was very cold during the winter and the development of the eggs slow.

In the rearing operations in 1889 at Craigs Brook, Me., Mr. Atkins succeeded in saving 97 per cent of the fish reserved and the eggs yielded 68 per cent of fish. The losses in winter were small.

Von Behr Trout (*Salmo fario*).

At Cold Spring Harbor, N. Y., 2½-year-old fish gave an average of 303 eggs each; 3½-year-old trout yielded 942 each. After the second year the growth of the brown trout is rapid.

At Northville, Mich., this species endures the climate well, and grows faster than the brook trout. Mr. Clark places from 10,000 to 12,000 eggs first upon gravel in a space 12 by 15 inches for about 40 days, or until the eye-spots begin to appear, when they are transferred to trays for hatching.

The average number of eggs furnished by 314 females was 520 each. The season began October 21, 1889, and closed January 2, 1890.

Loch Leven Trout (*Salmo levenensis*).

In the season of 1889–90 the loss in hatching Loch Leven trout at Northville, Mich., was only about 4 per cent. In attempting to rear fry hatched there from 13,000 eggs obtained from Germany, in March, 1890, the young, after the absorption of the yolk sac, commenced dying from some unknown cause, and 75 per cent were lost.

The average yield of 357 females was about 800 eggs each.

Rainbow Trout (*Salmo irideus*).

Mr. Clark reports that Northville, Mich., appears to be an unfavorable locality for rainbow trout. Upward of 19,000 yearlings were distributed between September 17, 1889, and March 10, 1890. The average yield of 123 females in the season of 1890 was about 968 eggs. The spawning season began January 4 and closed April 16, 1890.

Brook Trout (*Salvelinus fontinalis*).

The spawning season of 1889 began at Northville, Mich., October 14, 1889, and closed January 6, 1890.

By the use of gravel boxes the loss in hatching was only 2 per cent. A large proportion of the eggs were obtained from fish 18 months old.

On January 16, 1890, there were received at Neosho, from Northville, 25,000 eggs in excellent condition. When the embryo sac was two-thirds absorbed, a white spot appeared in the sac and almost exterminated the fry.

Whitefish (*Coregonus clupeiformis*).

There was an early run of whitefish to the spawning grounds in Lake Erie in 1888, but nearly all of the many eggs taken were lost. On Detroit River the penned fish did not do well. The warm weather was supposed to be the cause of the want of success with the eggs; the same thing happened at Sandwich, Ontario. The river water registered 50°.

At Alpena, Mich., eggs were collected from December 2, 1889, and the season closed at Thompson, December 14, with what is called the late run. On account of the warm weather the eggs at Alpena commenced hatching 15 to 20 days earlier than in former seasons; the first fish appeared April 5, and the last May 5, 1890.

The Vendace (*Coregonus albula*).

On April 12, 1888, 51,000 fish of this species, one month old, were planted in Heart Pond, Me., by Mr. Atkins.

Yellow Perch (*Perca flavescens*).

In April, 1889, the eggs of the yellow perch were successfully hatched by Mr. Worth at Central station. Adults from the Potomac River spawned naturally in the aquaria, and their eggs were placed in the universal hatching jars and developed almost without loss. The eggs were an oblong mass of fleecy texture, several inches long and heavier than water. The fry were very small; they were retained at the station in a small pond, and kept under observation.

On February 7, 1890, Mr. S. G. Worth obtained 243 adult yellow perch from the Potomac River. These were kept in running water at Central station until they deposited and fertilized their eggs naturally. The eggs were hatched successfully, with very small loss, and 704,000 fry were liberated in the Potomac River, and 50,000 in a private pond.

Pike Perch (*Stizostedion vitreum*).

The eggs of the pike perch, writes Mr. Douglass, of the Sandusky station, are about one-half as large as whitefish eggs. They are strongly adhesive, and great loss is sustained in separating them. The young begin to devour each other when only ten days old, and must therefore be liberated as soon as hatched.

Sea Bass (*Serranus atrarius*).

From June 5 to 10 about 1,150,000 eggs were collected at Woods Holl, Mass.; of these, 1,025,000 were hatched and the fry planted between June 10 and 13, 1889.

The collection of eggs for the Woods Holl station began May 23, 1890, and closed June 20. The number taken was upward of 4,250,000, of which 90 per cent were hatched in Chester jars and McDonald boxes. The shortest hatching period was 70 hours, with an average temperature of 64°; the longest period was 127 hours, when the temperature averaged 56°. The fish were liberated near the station.

Black Bass (*Micropterus salmoides*).

At Neosho, Mo., the black bass were expected to spawn in the ponds in the spring of 1890, but although they were tame and thrifty they deposited no eggs. In one pond they were attacked in the mouth by leeches and have not flourished.

Sheepshead (*Archosargus probatocephalus*).

On March 19, 1889, Lieut. Robert Platt, U. S. N., found sheepshead spawning at Boca Grand Pass, Fla., and collected 3,400,000 eggs. He then went to San Carlos Bay, about 30 miles distant, and found the fish abundant there and in spawning condition. He obtained in all 23,400,000 eggs, from which 14,000,000 healthy fry were developed, and 2,500,000 eggs were retained in the jars to be transported North. Lieut. Platt describes the eggs as follows:

> The egg of the sheepshead is a floating one and transparent; very small, 50,000 to the fluid ounce. We placed in the hatching jars about 300,000; they came out in forty hours, and can be liberated when seventy-two or eighty hours old. The fry are very small, but active and strong, and will stand considerable rough usage. We found that it was labor in vain to seine for spawning fish during the morning or ebb tide. The proper time is just before sundown, just as the flood tide begins to

make. At that time we would collect all the spawn we could handle. The morning hauls of the seine included nothing but male fish. The sheepshead when in spawn swim in schools, but not near the surface. They seem to like to swim close along the sandy beach in about 6 or 7 feet of water. At times our seine would have so great a quantity of these fish in it that we could not get it to the shore, but would have to raise the lead line from the bottom and liberate a great many so that we could examine those remaining in the net.

The apparatus used in hatching these eggs was the Chester jar in the tidal box.

Scup (*Stenotomus chrysops*).

May 22, 1889, 50,000 scup eggs were collected; 30,000 of these were hatched and the fry planted in Woods Holl Harbor May 29.

On June 14 and 16, 1890, about 444,000 eggs of this species were obtained for the Woods Holl station. These were placed in a Chester jar and a McDonald box. The first lot hatched in 72 hours at an average temperature of 61½°, the second lot in 95 hours when the temperature averaged 62½°.

Spotted weakfish (*Cynoscion maculatum*).

On April 1, 1889, Lieutenant Platt collected 1,450,000 eggs of this species at San Carlos Bay, Florida. He found the fish in great quantities, and the spawning season just beginning. He states that the egg floats, and is equal in size to that of the sheepshead. Only about 350,000 fry were developed. The period of hatching is 40 hours.

Squeteague (*Cynoscion regale*).

On June 6, 1890, there were obtained at Woods Holl, Mass., 237,700 eggs, of which 95 per cent were hatched in the Chester jar. The time of incubation was 65 hours, and the temperature 60°.

Pompano (*Trachynotus* sp.).

At San Carlos Bay, Florida, Lieutenant Platt seined a pompano weighing 18½ pounds. In the stomach he found crushed scallop shells.

Mackerel (*Scomber scombrus*).

Vinal N. Edwards, on May 21 and 24, 1889, collected 215,000 mackerel eggs, from which 150,000 fry were hatched and planted in Vineyard Sound, May 29. On June 3 500,000 eggs were taken from fish which had been dead a few minutes; none of these eggs survived.

Eggs of the mackerel were collected for Woods Holl station on June 2, 6, 10, and 11, 1890. The total number obtained was nearly 3,000,000, and the percentage hatched from good eggs was 89. The shortest hatching period was 72 hours, at an average temperature of 61°, and the longest period was 103 hours, when the average temperature was 59°.

Tautog (*Tautoga onitis*).

Eggs of this species were taken at Woods Holl May 21, June 10, 21, and 24, 1890. The total number collected was 808,605, of which 90 per cent were hatched. The shortest hatching period was 66 hours, on an average temperature of 64° to 64½°; and the longest period 144 hours, with a temperature of 56°. The Chester jars and the McDonald box were used.

Cod (*Gadus morrhua*).

At Gloucester, Mass., November, December, and January are the best months for collecting cod eggs. 161 female cod furnished on an average 279,000 eggs.

At Woods Holl, Mass., according to the report of the superintendent, the period of incubation in the McDonald tidal box averaged 18 days; in the Chester box, 20 days.

Mr. Richard Dana counts 18 cod eggs to 1 inch, from which basis he obtains:

In 1 quart	336,798
In 1 pint	168,399
In 1 gill	42,099
In 1 ounce	10,254
In 1 cubic inch	5,832

In 1889 the first cod for breeding purposes were received at Woods Holl on October 27; by November 19, 3,403 had been received, sufficient for the season's work. The fish were placed in live cars except 700, which were confined in a basin wherein the tide ebbs and flows. In this basin the mortality was great, probably owing to the high temperature, 55°, and the want of shelter from the sun. The eyes of many of the fish protruded from their sockets, and the fish became blind in six or seven days after their receipt. Board floats were then placed in the basin, after which the condition of the fish improved. When the temperature of the water fell to 46° the mortality decreased.

The first ripe eggs were taken November 18, and from this time until February 18, 1890, the number of gravid females handled was 91, which furnished about 8,500,000 eggs. From these upward of 5,750,000 fry were produced, which were liberated in the harbor from three to six days after hatching. The percentage of eggs hatched was 68. On February 11, 1890, were received from the Gloucester station 2,374,200 eggs. About 23 per cent of those received alive were hatched, the injury in shipment having been very great. On April 14, 1890, another shipment of 621,600 eggs was received from Gloucester, and of the number received alive 66 per cent were hatched. The hatching apparatus consisted of 40 Chester tidal boxes with a capacity of 6 hatching jars, each holding from 150,000 to 200,000 eggs, besides 47 McDonald tidal boxes each having a capacity of 500,000 eggs.

The temperature of the water in the hatchery ranged from 47° to 33° with no sudden changes and with unusual immunity from slime and sediment. The small supply of eggs alone prevented a large output of fry. The experiment of keeping cod in aquaria after the sac was absorbed proved again unsuccessful. The cod fry were generally liberated on strong ebb tide in Buzzards Bay or Vineyard Sound, so that they might quickly be carried into deep water. The average yield of the female cod at this station was nearly 94,000 eggs. In fertilizing these eggs the milt of 102 males was used. The shortest hatching period was 107 hours, from eggs obtained November 18, 1889, which were hatched November 23. The longest period was 696 hours, from eggs taken January 27, 1890, and hatched February 14. The average temperature during the hatching of the first lot was 47°. The maximum temperature during the incubation of the second lot was 38°, the minimum 34°, and the average 36°.

While the *Grampus* was obtaining cod eggs in October, 1889, it was found that few ripe fish were taken with hand lines as compared with those caught with the nets and trawls.

Capt. Fred. W. Wilson, under date of Febuary 12, 1889, stated that he has fished most of the time in winter off Gloucester, Mass., for fifteen years past. In the winter of 1887-88 and 1888-89 he saw an unusual number of small cod on hard bottom everywhere in the vicinity. They ranged from 5 to 10 inches in length, and toward the end of January he saw some that weighed about ½ pound. Captain Wilson says the cod are credited to the hatchery on Ten-Pound Island, and if one-half of the number taken on his vessel reach maturity the success of the work will be established. Capt. Isaac Joyce about the same time made a similar report; he believed that the young were more plentiful in the winter of 1888-89 than ever before; the smallest ones taken by him were about 8 inches long. Capt. Henry S. Jacobs, on February 11, 1889, wrote that more small cod were seen in the fall and winter of that year, from the range of Thatcher's Island to the range of Half-Way Rock, than during any other season in his experience. A large number of fish 9 inches long were among those taken. On three occasions 1,000 pounds of such cod were caught at one haul. He attributes the increase of cod to the work of the hatchery at Gloucester, Mass.

The difficulties experienced in keeping the cod eggs afloat at Gloucester, Mass., have already been mentioned, and also the fact that eggs which sink do not always fail to hatch. The difficulty with these eggs led Mr. W. H. Lynch, machinist, to the use of aquaria jars with water coming in from below and the top covered by cloth to retain the eggs. He suggested, also, placing a perforated ⅜-inch composition pipe along the bottom of the hatching trays and connected by rubber tube with the supply pipe, producing an upward current which would float the eggs.

The egg collecting began October 23, 1889, and continued until May 6, 1890. January and February were the best months. The largest yield in one day was nearly 3,500,000 on February 1. The number from 242 females was about 47,500,000, an average of nearly 200,000 to each female.

Hatching eggs in roily water.—In hatching eggs of the cod, haddock, and pollock at Gloucester, Mass., great mortality was caused by roily water, the sediment adhering to the eggs and causing them to sink. This difficulty was partly overcome by the use of the automatic jet; for the bulk of the eggs it served the purpose admirably, but greater difficulty was experienced in keeping cod eggs in circulation; many of them (apparently fertilized) sank to the bottom, and most of them failed to develop. By increasing the circulation after storms, many eggs that had sunk were cleaned and again became buoyant and hatched, yielding a fair percentage of fry, and in some cases eggs that remained on the bottom were developed and the young fry appeared vigorous.

Haddock (*Melanogrammus æglefinus*).

The receipts of haddock eggs at Gloucester, Mass., during the latter half of the season were very large, but the percentage hatched was very small, the methods now in use for developing these eggs not proving satisfactory. The first eggs were taken February 13, 1890, and the last May 7, 1890. The fry were liberated in the outer harbor from April 12 to May 8. The eggs were obtained from 240 females, the average yield for each being 126,000.

Pollock (*Pollachius virens*).

The spawning season for pollock at Gloucester, Mass., includes October, November, and a part of December.

The first eggs were taken October 30, 1888, and the last December 17, 1888.

The period of incubation varied from seven to twelve days.

During November 50 females furnished 20,256,300 eggs, an average of 405,125 each. From December 3 to 17, 39 females furnished 11,623,500 eggs, an average of nearly 300,000 each.

On October 30, when the first eggs were taken, the temperature of the water at noon was 48°, and its density 25. The temperature of the air at noon on the same date was 48°. During November the temperature of the water at noon ranged from 41° to 49°; the lowest temperature being observed from the 23d to the 26th, both inclusive.

The density of the water during this month was from 25 to 26.

The air temperature at noon during November varied from 24° to 59°, the lowest temperature having been reached on November 23. From December 3 to 17 the water temperature at noon ranged from 38° to 45°, and its density from 25 to 26°.

The eggs of the pollock are small and tender—much more so than those of the cod. They are adhesive after three days' time, and require very pure clear water, and no motion whatever. The eggs measure 22 to the lineal inch, and a quart contains 614,172. Some eggs were tried by liquid measure and numbered 19,216 to the ounce.

Pollock when hatched are transparent, and almost of the same color as the sac; they will burst from the shell in seven or eight days; they are weak and lifeless for a time, then they begin to dart from place to place like the cod, and stop quite suddenly as if entirely exhausted. The eye is not very distinct, and the fish appears blind unless closely observed. The spawning season is short compared with that of the cod.

The eggs of this species were circulated at Gloucester, Mass., without difficulty by means of the automatic jet. The first eggs were received October 18, 1889, and collections continued until December 20. The largest number obtained in one day was upward of 5,000,000, on November 7; about 40,000,000 were taken in all. The number of females furnishing these eggs was 181, and the average yield of each was nearly 222,000. Nearly 15,000,000 fry were developed, all of which were liberated at Gloucester; the first on October 27, obtained from eggs collected October 18, and the last on December 29, from eggs obtained December 20, 1889.

Flatfish (*Pseudopleuronectes americanus*).

At Woods Holl, from February 3 to April 24, 1890, the number of females handled was 87, which yielded 5,848,000 eggs. Over 4,000,000 fry were produced, which were liberated from 2 to 5 days after hatching. The average number of eggs to the female was 67,220. The period of incubation is about 20 days. The adults were caught in a fyke net. In severe cold spells the fish leave the harbor and go into the deep water of Vineyard Sound and Buzzards Bay, but return when the temperature rises so that the anchor frost disappears.

Sole (*Solea solea*).

On October 6, 1888, the Commissioner deposited in Vineyard Sound, near Quick's Hole, 28 soles which had been received from time to time at Wood's Holl from England.

Lobster (*Homarus americanus*).

On June 16, 1888, car No. 3 left Woods Holl with 610 lobsters for the Pacific coast; 282 died en route. The survivors were planted at Monterey, July 1, 2, 3, 4, 5 and 6. Out of 196,000 eggs taken with the adults, 92,000 were lost in transit.

The experiment of acclimating lobsters on the Pacific coast was renewed in 1889. An account of the shipment will be found in the Bulletin of the U. S. Fish Commission for 1888, pp. 453–472.

The attempt to rear young lobsters in large numbers at the Woods Holl station was again unsuccessful.

On March 28, 1890, there were 745 lobsters, measuring from 7 to 10 inches in length, shipped from Woods Holl in wooden crates, packed in seaweed, for the Gulf of Mexico, near Galveston, Tex. Of these 385 were females, 37 of which had their eggs fertilized, and 360 were males. On April 7 the eggs, numbering 250,000, were planted near Galveston. The fresh water of the bay proved fatal to the adults.

For the hatching operations at Woods Holl lobsters were obtained from the local fishermen. After the eggs were stripped off the females were marked and returned to the grounds from which they were caught, the object being to ascertain how often they deposited their eggs under natural conditions. Collecting began April 16, and by June 30, 1890, there were received 723 egg lobsters, varying in length from 9 to 14 inches. From these were obtained 8,317,600 eggs, which produced about 4,500,000 of fry. These were liberated in Vineyard Sound and Buzzards Bay, in the vicinity of Woods Holl, from two to four days after hatching. The percentage hatched was 54. The apparatus used were the McDonald improved hatching box, the Chester jar, and the McDonald universal hatching jar. The first two were operated by tidal motion, the latter by a continual current through the jar. The longest incubation period of eggs received here was 42 days and 3 hours. These eggs were taken April 22, 1890, when the water temperature was 45°, and the lobsters were well developed in the eggs at the time of collection. They did not hatch until the water reached a temperature of 59°. A lobster with eggs, said to be about to hatch, and in which the embryo was well developed, was brought in when the temperature was 36°, but no increase in development was noticed until May 18, after a period of 99 days, when the water reached 54°. A few fry were retained in the jar in which they were hatched, and in six weeks after hatching were transferred to an aquarium.

Common Pacific crab (*Cancer magister*).

In July, 1888, Prof. Leslie A. Lee and Mr. J. F. Ellis, collected live crabs (*Cancer magister*) at San Francisco, Cal., for transportation to the Atlantic coast on car No. 3 of the Commission. The entire shipment was lost by the wrecking of the car.

4.—NOTES ON A COLLECTION OF FISHES FROM THE LOWER POTOMAC RIVER, MARYLAND.

BY HUGH M. SMITH, M. D.

[Plates XVIII–XX.]

No systematic collecting has been done in the region drained by the Lower Potomac and its numerous tributary streams, and any contribution to a knowledge of the fish life of that section will probably be acceptable, as tending to aid in the elucidation of the problems of geographical distribution and variation. The only researches thus far made embracing the fish fauna of the region covered by this paper were undertaken by the Maryland Academy of Sciences, the results of whose investigations were embodied in an annotated list prepared by Messrs. Uhler and Lugger, published in the report of the commissioners of fisheries of Maryland for 1876, which was followed by supplements in the reports for 1877 and 1878. This list, enumerating 202 species, is the only one thus far compiled that essays to include all the fishes occurring in the waters of the State, and, while now subject to considerable revision in the matters of nomenclature and distribution of fishes, must serve as a comparison and guide for future inquiry.

The Lower Potomac River has a great wealth of fish, upon whose abundance and movements a large number of people are dependent. Not only is there a plentiful supply of desirable food-fishes which are more or less permanently found in the region, such as the yellow perch and striped bass, but there are very important annual migrations of anadromous species, as the shad and alewives; while the proximity to the Chesapeake Bay (whose commercial fisheries are of greater value than those of any other body of water of like size in the world) also contributes a generous supply of typically salt-water fish. The topographical conditions are favorable to the employment of seines, gill nets, pound nets, fyke nets, and other similar devices in almost unlimited numbers. This fact, together with the abundance of oysters and crabs, in addition to fish, makes this one of the most important fishing-grounds in the country.

In the summer of 1890 I made two short visits to St. George Island, Maryland (situated in the Potomac River, about 15 miles from its mouth), and at the suggestion of Dr. T. H. Bean, ichthyologist of the U. S. Fish Commission, obtained a small collection of fishes. Owing to the limited time available for collecting and lack of facilities for preserving the larger fishes, attention was chiefly directed to the smaller forms

inhabiting the shallow inshore waters, and many species that could otherwise have been taken do not, therefore, appear in the list. During the first visit, which extended from June 30 to July 6, the only means of capture was a small dip net with an improvised handle—an instrument of necessarily limited usefulness in such work. On the occasion of the second visit, which occupied one day, August 11, a 25-foot Baird seine was employed with satisfactory results.

The smaller species included in the list were secured in a series of brackish ponds on St. George Island, or in St. George River, an arm of the Potomac which separates the island from the mainland. Complete series of most of these were preserved. The larger fishes which are enumerated were taken with a line or in pound nets in the Potomac River adjacent to the island. Two specimens obtained in this locality in August, 1887, which were not observed in 1890, are also included. The names by which the fish are known among the local fishermen are given in quotation marks.

Although the collection was made in a hurried and unsystematic manner, and represents only a very small proportion of the fishes occurring in the region, the visit was not wholly lacking in scientific results, which emphasize the desirability of undertaking further investigations of the ichthyology of this river. Most of the species obtained possess no unusual interest. In a few cases, however, it has been possible to fully describe and figure for the first time the appearance of young individuals of certain common fishes; and, in another well-known species, an apparently hitherto unrecognized sexual distinction is recorded. The most interesting and important feature of the collection was the finding of a small fish (*Zygonectes luciæ*) first described nearly forty years ago by the late Prof. Baird, and up to this time known only by his description, the type specimens apparently having been lost.

Ten figures, representing seven species, accompany this article, viz: *Zygonectes luciæ*, male; *Fundulus majalis*, young; *Fundulus diaphanus*, male and female; *Fundulus heteroclitus*, male; *Cyprinodon variegatus*, male and young; *Gambusia patruelis*, female; *Menidia beryllina;* and *Paralichthys dentatus*. Some of these have never before been figured.

1. Brevoortia tyrannus (Latrobe). *"Ellwife"; "Oldwife"; "Alewife"; Menhaden.*

Large bodies of menhaden often ascend the Potomac River for a distance of 30 miles, and the vessel fishermen from Fairport not infrequently make good hauls off St. George Island. Schools of young fish swimming in serpentine shape can be seen breaking the surface of the inshore waters throughout the summer. All of a large number of young fish (about 2 or 3 inches long) examined were affected with a mouth parasite (*Cymothoa prægustator*). Occasionally, during periods of excessively dry weather, scattered schools of menhaden ascend the river as far as Mount Vernon, where the species is called "bugfish" by the fishermen.

2. Cyprinodon variegatus Lac. *"Sheepshead minnow"; Variegated minnow; Short minnow.* (Pl. XVIII.)

Although inhabiting the same waters as *Fundulus*, the variegated minnow does not appear to associate with the members of that genus. In small ditches communicating with the St. George River at high tide the movements and habits of the fish were studied with ease and profit. They were extremely shy and could not be taken with a dip net, however skillfully manipulated. In the pond of brackish water elsewhere referred to they occurred in great abundance, and numerous species of both

sexes and all sizes were seined. Large schools of the young are often left, by the receding tide, in shallow depressions in the sand.

Several young specimens, about seven-tenths of an inch in length, agree in having the body silvery white, with about eight irregular crossbars and with irregularly rounded blotches of similar color along the back, some of these communicating with the transverse markings; a narrow blackish bar at base of caudal; a rounded black spot on posterior part of dorsal; dorsal fin slightly behind (not in advance of) ventrals; a quadrate black spot about half width of eye immediately below that organ.

In the adult specimens collected and in the male figured the origin of the dorsal fin is well in front of the ventrals and not behind, as given by Jordan and Gilbert.*

The variegated minnow is known as the "sheepshead minnow" among fishermen of the island, a name arising from the resemblance between this fish and the sheepshead, and also, in some instances, from the belief that it is the young of that species.

Eighty-nine specimens.

3. **Fundulus majalis** (Walbaum). *"Bull-minnow"; Mayfish.* (Pl. XIX.)

The least abundant of the killifishes. In company with the two following species it enters the guts and ditches on St. George Island at high tide, and the specimens collected were taken in these situations. Eight adult specimens were obtained, four being of each sex. The males varied from 4.50 to 5.12 inches in length, and the females from 4.00 to 5.75 inches, the average length being 4.69 inches for males and 4.97 inches for females.

Nine specimens of apparently young fish are referred to this species. They much resemble *F. majalis* in general shape, but differ somewhat from the published descriptions in color, markings, fins, etc., as will appear from the following description:

Color in life, silvery white, becoming pale green on the back. Body with 7 to 9 dark transverse bars (black in life) one-half the width of eye in some specimens, narrower in others, beginning at the median line of the back, but not quite reaching the middle line below, the last bar much darker than the others and frequently taking the form of an irregular spot at the base of the caudal fin. Fins white, unmarked. Body elongated. Head long, depressed, terminating acutely; mouth terminal, slightly oblique. Eye somewhat less than snout and contained $1\frac{1}{2}$ times in interorbital space. Anal fin higher than and posterior to dorsal and equal to half length of head. Ventrals short, not reaching anal. Tail rounded. Head, 3; eye, 4; depth, $4\frac{1}{2}$. Dorsal, 13 or 14 (15 in one specimen); anal, 11. Scales in lateral line, 33 to 37; in transverse line, 13. Length, $\frac{7}{8}$ to $1\frac{3}{16}$ inches. Abundant in low, sandy places where shallow pools are left by the receding tide.

4. **Fundulus diaphanus** (Le Sueur). *Spring minnow.* (Pl. XIX.)

The most abundant of the killifishes, occurring with *F. heteroclitus* in tide ditches and brackish ponds.

Examination of a large series of specimens collected in this region leads to the conclusion that there are prominent sexual differences which do not appear to have been previously noted. Concerning the crossbars which form such a noticeable feature in this species, the current descriptions give 15 to 25 narrow, blackish bars on a silvery background. This description, so far as the fish collected by the writer in the

*Synopsis of the Fishes of North America.

Potomac River are concerned, seems to apply only to the females, while the males have a similar number of brilliant silvery crossbars on an olivaceous background. This conclusion is borne out by the examination of 71 adult males and 54 egg-bearing females.

The following description of the sexes, based on Potomac specimens, is offered:

Male.—Form elongated, slender. Head depressed, of moderate length. Dorsal fin low, beginning considerably in advance of anal and nearer base of caudal than snout. Anal short, deeper than dorsal. Ventrals about equal to portion of head posterior to eye, not reaching vent. Body uniformly olivaceous, darkest above, with about 20 silvery vertical bars, rather narrower than the interspaces, which are the color of the body. Dorsal usually plain, occasionally faintly mottled with black and white spots. Other fins plain. Mouth nearly horizontal, width of eye, on level with pupil, lower jaw projecting, angle of jaw half-way between eye and end of lower jaw. A dark purplish spot on opercle opposite eye.

Female.—Similar to male in form and size. The body marked by 15 to 20 dark transverse bars, much narrower and shorter than the silvery bars in the male, the interspaces lighter than in the male. Back sometimes spotted. Oviduct sheathing the anterior part of anal. Ventrals not reaching vent.

Eye large, $3\frac{1}{2}$ in head, $1\frac{1}{2}$ in interorbital space, and $1\frac{1}{3}$ in snout; head, $3\frac{1}{2}$; depth, $4\frac{1}{3}$. Dorsal, 13; anal, 11. Scales, about 45–15. Length, $3\frac{1}{2}$ or 4 inches.

Prof. Jordan, in his "Report of Explorations in the Alleghany Region of Virginia, North Carolina, and Tennessee,"* etc., records the capture at Luray, Virginia, in the Shenandoah River, of a specimen of *Fundulus diaphanus* "with about 15 silvery crossbands, most of them narrower than the dark interspaces; back and fins unspotted." That form of *F. diaphanus* formerly called *menona* is said† to occasionally have silvery crossbars instead of black ones. These are the only references to silvery transverse bars met with in the descriptions of this species.

All immature specimens are distinctly marked by dark vertical bars, on a pale olivaceous background. When the fish reaches the length of about 2 inches, the differential sexual characters, as before defined, begin to be manifested. A series of 102 young specimens was preserved, the smallest being seven-eighths of an inch long.

5. Fundulus heteroclitus (L.). *Common killifish; Mud dabbler.* (Pl. XIX.)

Next to *F. diaphanus* this is the most abundant killifish in the region. 120 specimens were preserved, of which 81 were adult and 39 were immature individuals.

This species is subject to considerable variation in color, depending on sex and age. The complete series of specimens obtained has permitted a satisfactory diagnosis of even the smallest examples.

Among 36 adult males, the largest specimen is $4\frac{1}{2}$ inches long. As the male approaches maturity the distinct dorsal ocellus, which is more or less constant in the young, usually disappears, and it is rarely seen in adults, although in a few specimens the vestiges remain in the form of a dark spot on the already dark or mottled fin; the ocellus is rarely found in examples over $2\frac{1}{2}$ inches long. In some adults the white spots on the body, instead of being disposed in narrow vertical stripes and irregularly scattered over the sides, as usually described, are found on the anterior part of each

* Bulletin U. S. Fish Commission, VIII, 1888, p. 103. † Manual of the Vertebrates.

scale and form well-defined longitudinal and diagonal stripes, as in the specimen figured.

The female is usually described as having no transverse markings, but sometimes a "few faint vertical shades." Of the 45 adults preserved, 42 are marked with about 15 distinct dark crossbars narrower than the interspaces. The largest female obtained was $4\frac{1}{4}$ inches in length.

Large specimens have head $3\frac{1}{2}$; eye 4 in head, 1 in snout, 2 in interorbital space; depth $3\frac{3}{4}$.

Immature males differ greatly from the adults. The following description, based on a full series, applies to young males:

Body above light olive, below yellow, the sides marked by about 24 alternate dark and silvery transverse stripes, the former usually being considerably wider. As the size of the fish increases the back becomes darker and blends with the dark bars, leaving only the silvery bars, which become less distinct. In the smaller examples the silvery bars are about as wide as the dark ones. Dorsal dark, with a prominent white spot involving the last 3 or 4 rays, margined with black above and anteriorly. Anal much deeper than dorsal. Head, $3\frac{1}{2}$ to $3\frac{3}{4}$; eye, $3\frac{1}{4}$ in head, $1\frac{1}{2}$ in interorbital space, $\frac{2}{3}$ to $\frac{7}{8}$ in snout; depth, $3\frac{3}{8}$. Dorsal, 11; anal, 10 to 12. Scales, 37–13. Length, $1\frac{3}{4}$ inches.

All immature females have the colors of the adult females, but are somewhat paler, the blackish bars being more distinct. Head, $3\frac{3}{4}$; eye, $3\frac{1}{3}$ in head, $\frac{3}{4}$ in snout; depth, $3\frac{3}{4}$.

In 13 specimens from $\frac{7}{8}$ to $1\frac{5}{16}$ inches long, the differential sexual characters, as before defined, are distinctly present, the stripes being somewhat more prominent than in the half-grown fish. The dorsal markings in the males, however, are absent in such small examples. Head, $3\frac{1}{2}$; eye, $3\frac{1}{2}$; depth, 4. Dorsal, 11 or 12 (14 in one specimen); anal, 10 or 11. Specimens of *F. heteroclitus* of this size bear a strong superficial resemblance to *Zygonectes luciæ*, but are found to differ widely on close examination.

6. Zygonectes luciæ (Baird). (Pl. XVIII.)

Under the name *Hydrargyra luciæ*, Prof. Baird, in the Smithsonian Report for 1854, described a small minnow from Great Egg Harbor, New Jersey. The types are unfortunately not extant, so far as known, and since that time the fish has not been met with, although Dr. T. H. Bean, in 1887, made diligent search in the region in which Prof. Baird collected his specimens.

Two specimens, evidently males, taken on St. George Island, appear to agree remarkably well with the description of this fish, and no other disposition seems possible than to refer them to this lost species, a view which is shared by Dr. Bean. Prof. Baird's description is as follows:

General form elongated, though of rather short appearance. Head constituting less than one-fourth of total length. Insertion of anal slightly in advance of origin of dorsal, and rather more developed than the latter. Ventrals very small; their extremity reaching the anus. Tail large. D. 8; A. 9; C. 6, I. 8, 7, I. 5; V. 6; P. 15. Dark olive green above, lower part of sides and beneath rich ocher yellow. Sides with 10 or 12 broad, well-defined, vertically disposed dark bars, nearly as large as their interspaces, which are of a faint tint of greenish white. All the fins but the dorsal are of a uniform yellowish, lighter than the abdomen. Dorsal, yellow on the terminal half, the basal portions olivaceous, with a large black spot posteriorly, and immediately anterior to it a white one. The dark spot is bordered above and behind by the yellow part mentioned. In one specimen the posterior half of the base of the dorsal fin is dull white, with a large subcircular spot of black in the center. Length about 1 inch. Female similar, the dorsal unspotted, the yellow less intense.

The two specimens obtained in the Potomac River have the following characteristics:

Designation.	1.	2.
Length (inches)	1¼	1⅛
Head in length without caudal	3⅛	3⅛
Depth in length without caudal	4⅛	4¼
Eye in head	3+	3+
Eye in snout	⅜	⅜
Eye in interorbital space	1⅛	1¼
Dorsal rays	8	8
Anal rays	10	10
Scales in lateral series	35	34
Scales in transverse series	11	10

The dorsal fin has its origin posterior to that of the anal and is lower than the latter; when flexed, its extremity is opposite the tip of the anal. The ventral fins are small, about equal to head back of eye and half the length of the pectorals, their extremity reaching the anus.

The vertical bars are 10 to 12 in number, and are sharply defined, their width being equal to the interspaces and slightly increasing toward the tail. They begin and end abruptly, not reaching the median line above or below by about half the width of the eye.

The opercles, cheeks, and chin are thickly covered with dark spots, largest on the cheeks and opercles, and least numerous on the cheeks.

Field notes giving the color of the fish when alive agree with Prof. Baird's description. The upper parts were of a dark-green color, which faded into a reddish yellow on the sides and abdomen; the inferior fins were pale yellowish; the vertical bars were rich black, with a bluish reflection. The dorsal showed a pale tip and anteriorly a dark base; behind there was a jet-black rounded spot about two-thirds the width of the eye and involving rather more than half the width of the fin, margined anteriorly and inferiorly by a pure white spot.

The species appears to belong in the genus *Zygonectes*, as defined by Prof. Jordan, which differs from *Fundulus* in the smaller size of the fishes, the fewer dorsal rays, and the origin of the dorsal behind the front of the anal.

The two specimens secured were taken in company with a large number of fish of a similar size and appearance with which they were at first thought to be identical. These have the distinct dark crossbars, but lack the dorsal ocellus and the yellowish color on the under parts. The absence of these features alone would suggest that they are females of *Zygonectes luciæ*, but when taken in connection with 10 to 12 rays in the dorsal fin and the position of the latter anterior to the anal, must necessarily place the fish in the genus *Fundulus*.

7. Lucania parva (Baird & Girard). *Rainwater fish.*

Not given by Uhler and Lugger in the list of the fishes of Maryland. It occurs in about twice the abundance of *Gambusia patruelis*, with which it is almost invariably taken. Most abundant in brackish muddy ponds and tide ditches.

Males with body olive green, the scales marked by black crescentic bands covering about the middle third of the exposed portion. An obscure, narrow, lateral stripe. Under parts and lower fins yellowish. A large elongated black spot at the base of dorsal anteriorly, involving about three rays and extending upwards from back to

middle of fin; posterior to the black spot is a yellow area (white in alcoholic specimens) without spots; the remaining part of the fin is irregularly spotted with black, more especially the base and extremity, leaving, in many specimens, an elongated space only sparingly marked with fine spots. Edges of anal and ventral fins jet black and of caudal and pectoral fins dusky. Females similar, larger, with fins unmarked. Dorsal, 10 to 12; anal, 10 or 11; head, $3\frac{1}{4}$; eye, 3; depth, $3\frac{1}{3}$; scales, 26 (25 to 27)–8 (or 7). Length of mature specimens, $1\frac{1}{8}$ to $1\frac{3}{4}$ inches. 146 specimens.

8. Gambusia patruelis (Baird & Girard). *Top minnow.* (Plate XX.)

Very abundant in shallow muddy ditches and in the brackish ponds elsewhere alluded to, always associated with *Lucania* and occasionally with the *Funduli* and *Menidiæ*. All of the larger females taken were distended with eggs, which are relatively large but few in number. Specimens collected July 1 contained from 18 to 30 ova, each one-sixteenth of an inch in diameter, which were not in an advanced stage of incubation. Examples obtained August 11, however, were found to contain well-developed embryos, which would doubtless have been extruded within a few days. Jordan* says the young are born in spring, which suggests that possibly two broods are raised in a single season. The stomach contents of one fish incidentally examined consisted chiefly of filamentous and unicellular algæ, diatoms, amorphous vegetable matter, and fragments of a mosquito.

Of the 69 specimens obtained, 68 were females, a circumstance illustrating the well-known relative scarcity of males. In the series collected the females have a few small scattered dark spots on the body and an obscure dark line along the side; dorsal shows about 2 or 3 transverse rows of black spots, anal edged with black, tail irregularly spotted, the spots tending to form 2 to 4 narrow transverse bars; usually a dark spot, purple in life, on side above vent; no "oblique dark band below orbit" (Jordan & Gilbert), although in a small proportion of the specimens there is a faint, dusky spot; snout with a very pronounced upward inclination. Male without purple spot on side, anal plain, snout less spatulate. Dorsal, 7 to 9; anal, 9 or 10; head, $3\frac{1}{2}$; eye, 3; depth, $3\frac{3}{4}$; scales, 28 (27 to 29)–7 (or 8). Length of adult females, $1\frac{1}{4}$ to $1\frac{3}{4}$ inches; of male, 1 inch.

9. Anguilla anguilla (L.). *"Eel."*

A single specimen, 4 inches long, was seined in a brackish pond inhabited by killifishes, silversides, etc.

10. Tylosurus marinus (Bloch & Schneider). *"Garfish."*

Examples under 8 inches in length are not infrequently seen in small companies around the wharves and shores. The fish move rapidly over the surface, feeding on small minnows and also on fragments of crabs and fish thrown into the water by line fishermen. This species ranges over the entire river to the limit of tide water, specimens being occasionally taken above Washington.

11. Menidia notata (Mitchill). *Silversides.*

Very numerous, but less so than *M. beryllina*, with which it associates. The specimens taken varied in length from seven-eighths of an inch to $3\frac{1}{2}$ inches, the average size being about $1\frac{7}{8}$ inches. The dorsal formula varied considerably, IV–I,8, IV–I,9, V–I,8, V–I,9, V–I,10 all occurring, but V–I,8 and V–I,9 being the most prevalent.

* Manual of the Vertebrates.

The anal rays were found to number from I,22 to I,27. In the following table is given a record of the examination of a series of this species taken at random from among the largest specimens obtained:

No. of specimen.	Length.	Dorsal.	Anal.	Head.	Depth.	Eye.	Scales.
	Inches.						
1	2	V-I, 9	I, 25	4+	4⅛	3	45
2	2	V-I, 10	I, 25	4⅛	4⅛	3—	45
3	1⅞	V-I, 9	I, 22	4+	4⅛	3	43
4	1⅞	IV-I, 9	I, 23	4⅛	4⅛	3	45
5	1⅞	V-I, 8	I, 23	4	4⅛	3	43
6	1⅛	IV-I, 8	I, 22	4	4⅛	2⅞	43
7	3⅛	V-I, 8	I, 24	4⅛	6	3½	45
8	2	V-I, 8	I, 25	4⅛	4⅛	3	46
9	1⅞	IV-I, 8	I, 23	4	4⅛+	3	44
10	1⅞	V-I, 9	I, 27	4⅛	4⅛	2⅞	46

12. Menidia beryllina (Cope). *Silversides.* (Plate XX.)

This species, originally described by Cope from the Potomac River, occurs abundantly in large schools in this portion of the Potomac. The writer has also taken specimens at Washington, D. C.

The examples examined appear to differ in some minor details from the published descriptions of the species, as will be seen from the appended comparative table, which represents fish taken at random from a large series. The dorsal formula would seem to be V–I,10 rather than V–I,11, the latter being found only once in a large number of specimens and being less frequent than V–I,9. The anal rays vary from I,15 to I,18, the latter representing the maximum and not the average, as usually given, which would seem to be I,16 or I,17.

No. of specimen.	Length.	Dorsal.	Anal.	Head.	Depth.	Eye.	Scales.
	Inches.						
1	2⅛	V-I, 10	I, 17	4⅛	6	3	40
2	2⅛	V-I, 10	I, 17	4⅛	6	3+	40
3	2⅛	V-I, 10	I, 18	4	5⅞	3	38
4	2⅛	V-I, 10	I, 18	4	5⅞	3	39
5	2⅛	V-I, 10	I, 16	4⅛	6	3	40
6	2⅛	V-I, 10	I, 17	4	6	3	39
7	2⅛	V-I, 11	I, 16	4	6	3	38
8	2⅛	V-I, 9	I, 16	4	6	3	40
9	2⅛	V-I, 10	I, 15	4⅛	6+	3	39
10	2⅛	V-I, 10	I, 18	4⅛	6	3—	40
11	2⅛	V-I, 10	I, 15	4⅛	5⅞	3	40
12	2⅛	V-I, 10	I, 18	4+	5⅞	3—	40
13	3⅛	V-I, 9	I, 16	4⅛	6	3	40

Specimens numbered 5, 7, 8, 9, 11, and 13 in the table resemble *Menidia peninsulæ* in the number of anal rays, but differ from that species in having from 9 to 11 rays in the second dorsal, instead of 8.

The silvery stripe in this species is said to be on "two half rows of scales," but this designation will not strictly apply to the specimens from the lower Potomac. In all those examined the stripe involves different rows in different portions of the fish. Anteriorly it is found on the lower half of the fourth row and the upper half of the fifth row; toward the middle, opposite the dorsal fins, it involves the central portion of the fourth row and the tips of the scales in the third and fifth rows; toward the tail the line appears to rise and covers the lower half of the third row and the upper half of the fourth row.

13. Scomberomorus maculatus (Mitchill). *"Spanish mackerel."*

This fine food-fish is not uncommon in the mouth of the Potomac and for a short distance upstream. Considerable numbers are taken some seasons in pound nets and other devices. The fish are usually small, averaging only 1½ pounds in weight, but some years there appears to be a run of much larger individuals. In August, 1888, the writer saw a specimen weighing 7¼ pounds taken in this locality in a pound net; this seems to be the maximum weight attained by the species.

14. Pomatomus saltatrix (L.). *"Tailor"; Bluefish.*

The bluefish which ascend the Potomac are similar in size to those frequenting the Chesapeake; that is, they usually weigh from 1 to 3 pounds. Some years, as in 1888, there is a run of fish weighing 6 or 8 pounds, but individuals so large are rarely taken. Here, as elsewhere, the fish is erratic in its appearance and abundance.

15. Stromateus alepidotus (L.). *"Harvest fish."*

Uhler and Lugger remark regarding this species: "Occurs in Sinnepuxent Bay and in the southern part of Chesapeake Bay." A number of years' observations warrant the statement that the harvest fish is not uncommon in the waters adjacent to St. George Island, where individuals are seen every year, usually in the months of August and September, whence the name. The specimen which gives the species a place in this list was taken in August, 1887, in the St. George River; it was 2 inches in length. An interesting and well-recognized habit of the species is that of swimming beneath the body and among the tentacles of jelly-fishes; all the harvest fish observed in this region have been in this position. This is doubtless for protection.

16. Lepomis gibbosus (L.). *"Sunfish"; "Tobacco-box"; "Pumpkin-seed"; Robin perch* (Norfolk, Virginia).

Occurs abundantly in a small pond of brackish water on St. George Island inhabited by *Gambusia*, *Lucania*, *Menidia*, *Fundulus*, *Cyprinodon*, etc. The fish is eaten at times by the native inhabitants of the island, although this would seem to be only a caprice, with the wealth of more desirable fish close at hand.

Concerning the hitherto mooted question as to whether the male or female fish guards the nest, the weight of recent testimony appears to favor the former and confirms a single observation made at St. George Island. One day in July a crab was seen to invade the nest of a pair of sunfishes. The female retired to an adjacent growth of water plants, while the male made savage darts at the intruding crab or approached it cautiously from the rear, apparently inviting a chase. This continued for some minutes, when the crab appeared to tire and beat a retreat, whereupon the male sought his mate and both returned to the nest. The sex of the fish was afterwards verified by dissection.

Eighteen adults and 40 young specimens were preserved.

17. Roccus lineatus (Bloch). *"Rock"; Rockfish; Striped bass.*

Not common during summer, but quite abundant in spring and fall. Frequently found on hard sandy or gravelly bottom overgrown with *Ulva intestinalis*. In summer the specimens taken are usually under 3 pounds.

18. Archosargus probatocephalus (Walbaum). *"Sheepshead."*

To the shy habits and restricted feeding grounds the apparent scarcity of this species is to be attributed. An oyster bed in deep water is the place where the fish

can most frequently be found, and certain areas of this kind in the lower Potomac, known as "sheepshead rocks," have become famous for miles around. The fishermen often sink a number of long poles in favorite locations, and on these the barnacles soon grow and become attractive food for the sheepshead, which can often be taken in considerable quantities around the hurdles. In line fishing, blue and fiddler crabs and maninoses are the best baits.

Mr. P. L. Uhler, in the list of the fishes of Maryland, refers to this fish as weighing from 10 to 25 pounds; but specimens even as large as the minimum weight mentioned must now be very rare in the Chesapeake and are never seen in the lower Potomac, where the fish usually range from 4 to 7 pounds.

On St. George Island, sheepshead intended for the table are often kept alive for several weeks in pens made for the purpose.

19. Liostomus xanthurus Lac. *"Spot"; "Crocus."*

Perhaps the most important food-fish in this region during the summer, although too small to be of great commercial value; enormous quantities are consumed locally at hotels and in private families, and it deservedly ranks as the best pan-fish. It is often called "crocus" by the local fishermen, a designation also shared by the croaker, of which name it is a corruption.

20. Micropogon undulatus (L.). *"Crocus"; "Grumbler"; Croaker.*

Although not uncommon, the croaker is much less abundant than its near relative, the spot, with which it associates. The largest individuals appear to occur towards the end of summer.

21. Menticirrus nebulosus (Mitchill). *Whiting; Kingfish; Barb.*

This fish must be of very rare occurrence in the Potomac River. Uhler and Lugger refer to it as being occasionally met with in the lower part of Chesapeake Bay. A small specimen was taken with a line in the St. George River in August, 1887.

22. Cynoscion maculatum (Mitchill). *"Trout"; Spotted weakfish.*

Occurs throughout the summer in varying abundance. In June the fish are mostly small, weighing only one-half a pound, but in August there is an advent of large fish ranging from 1 to 3 pounds, which remain in the region until October.

23. Batrachus tau (L.). *"Toadfish."*

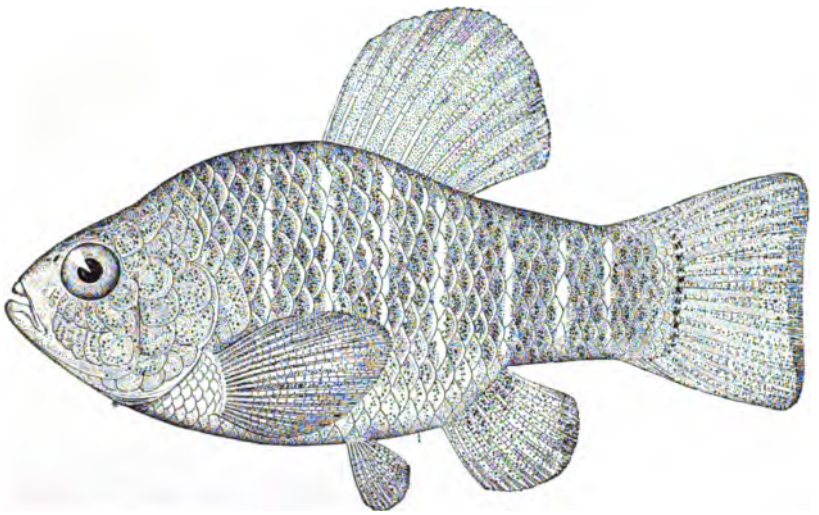
Exceedingly numerous, especially on oyster beds in shallow water. Takes the hook freely and at times is very troublesome to anglers. Not esteemed for food, on account of its extreme ugliness, but is sometimes eaten by negroes and is said to be well flavored.

24. Paralichthys dentatus (L.). *"Flounder": Summer flounder; Plaice.* (Plate XX.)

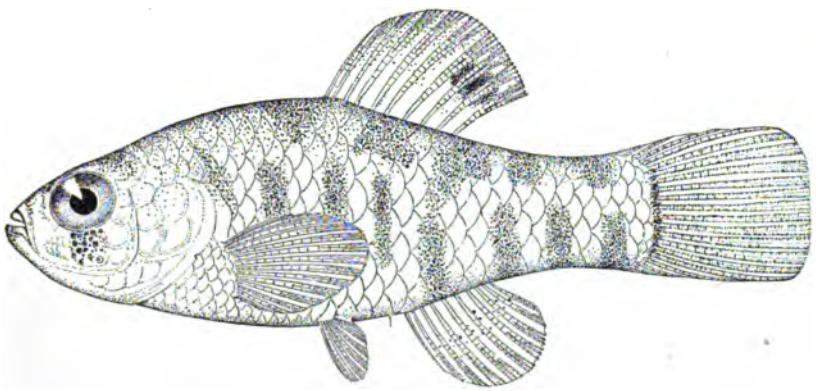
The common flounder of the lower Potomac during the summer months; it takes the hook readily, and when of large size is one of the most valued food-fish of the river.

Uhler and Lugger did not find this fish in Chesapeake Bay or its tributaries, but say that it has been occasionally taken on the coast of Worcester County.

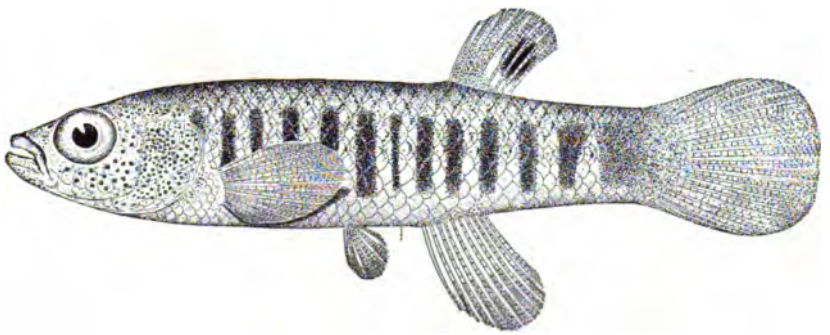
The specimen figured was about 6 inches long. The superior surface was of a uniformly brownish-olive color, with ten distinct ocelli consisting of a dark-brownish center with a pale border. The basal part of the caudal was obscurely spotted, and a single dark spot appeared on the middle of a few of the dorsal and anal rays.



CYPRINODON VARIEGATUS. *Variegated Minnow.* Male. Twice natural size.

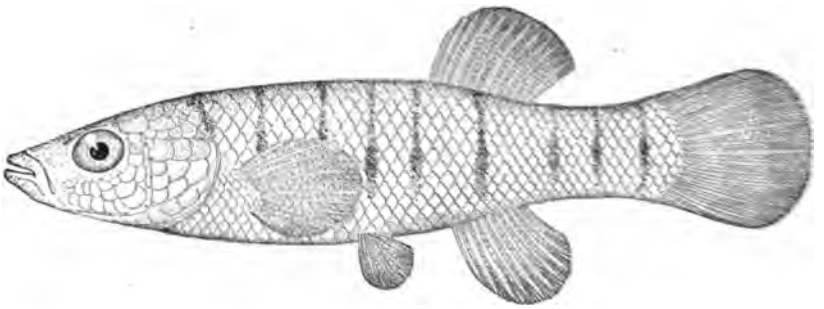


CYPRINODON VARIEGATUS. *Variegated Minnow.* Young. Six times natural size.

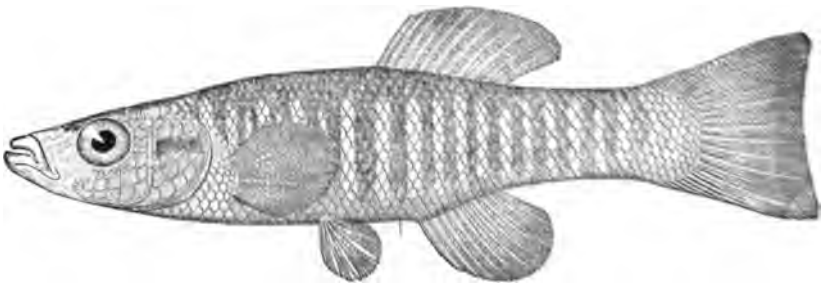


ZYGONECTES LUCIÆ. Male. Four times natural size.

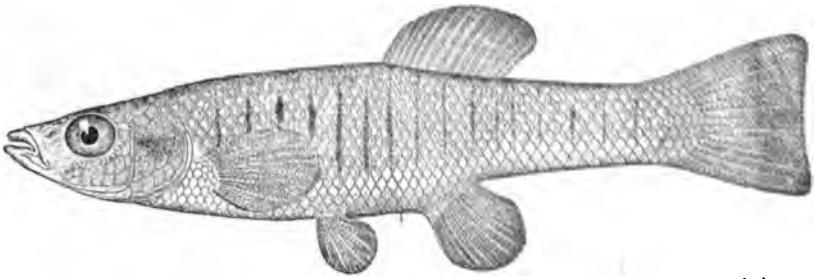
Bull. U. S. F. C. 1890.—(To face page 72.) Fishes from the Lower Potomac River.



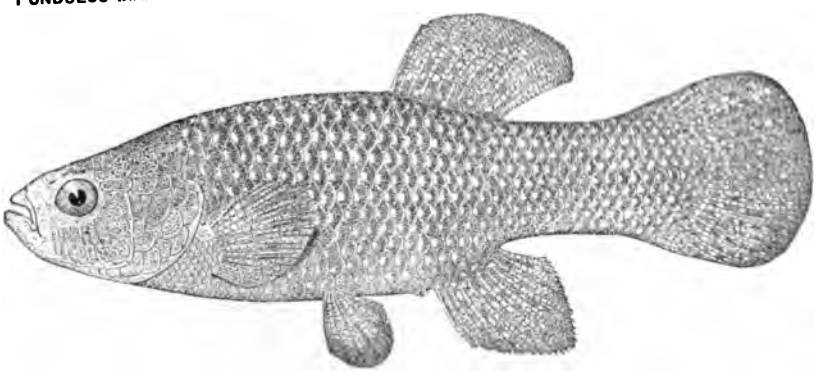
FUNDULUS MAJALIS. *Mayfish.* Young. Four times natural size.



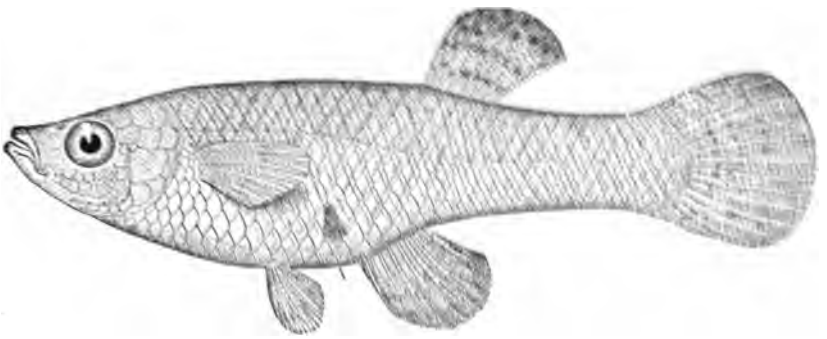
FUNDULUS DIAPHANUS. *Spring Minnow.* Male. One and one-fifth times natural size.



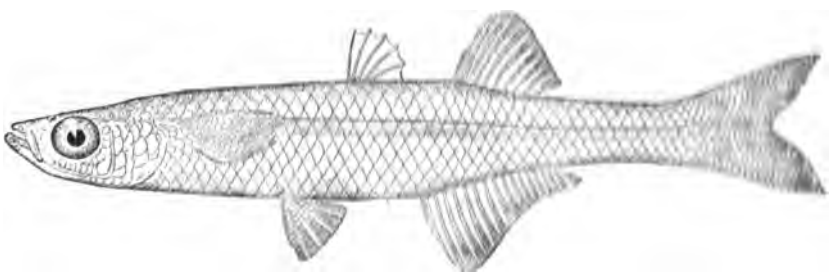
FUNDULUS DIAPHANUS. *Spring Minnow.* Female. One and one-fifth times natural size.



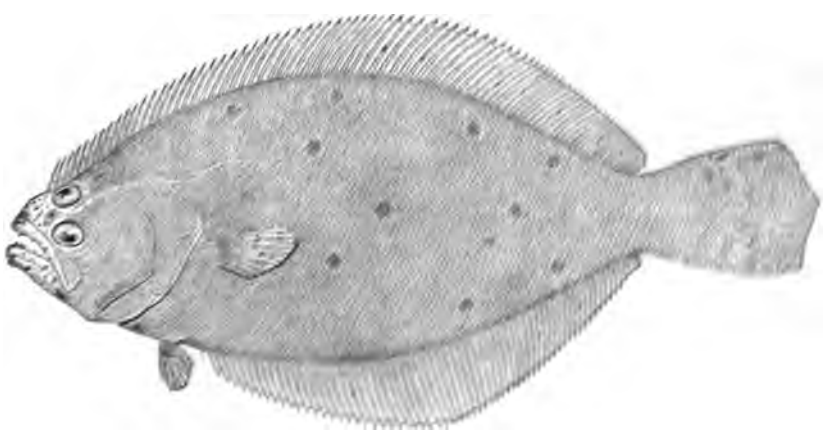
FUNDULUS HETEROCLITUS. *Common Killifish.* Male. Natural size.



GAMBUSIA PATRUELIS. *Top Minnow.* Female. Two and one half times natural size.



MENIDIA BERYLLINA. *Silverside.* One and one-fourth times natural size



PARALICHTHYS DENTATUS. *Summer Flounder.* Immature. Two thirds natural size

5.—REPORT ON THE FISHERIES OF THE NEW ENGLAND STATES.

BY J. W. COLLINS AND HUGH M. SMITH.

I.—GENERAL REMARKS AND STATISTICS.

The fisheries of the New England States are so well defined as to their character, methods, etc., and form such an important part of the industrial life of that section, that it is deemed proper to present a special paper dealing with their various phases, in order to exhibit their extent and condition in greater detail than would be practicable if the entire coast of the United States were under consideration.

The information herein given is similar in general scope, character, and arrangement to that contained in the "Statistical Review of the Coast Fisheries of the United States," recently published by the U. S. Fish Commission, but is much more detailed than ever before presented in the matter of minor civil divisions. It is thought that this feature of the paper will be received with favor, since it enables the reader to obtain the fullest statistical information concerning the extent of the fisheries in each coast county in New England. The material upon which the report is based was obtained by a personal canvass by agents of the U. S. Fish Commission of the 3,460 miles of coast line covered by the statistics. The report relates to the calendar year 1889 and includes the entire commercial fisheries of the New England coast. Under each State will be found a definite statement of the extent to which the various rivers were investigated; in general, however, it may be said that all streams were canvassed to the limits of economic fishing, and the report may therefore be regarded as a complete exposition of the fisheries and fishery industries of this section.

The tables have been compiled and arranged with the purpose of exhibiting the different phases of the fisheries under the following heads:

1. Civil divisions: A clear conception can be obtained of the relation of the fisheries, not only to each State but to each county along its coast.

2. The vessel and shore fisheries: These are exhibited in such a manner as to show definitely the extent and value of each.

3. The value of fisheries by apparatus: These tables show the relative effectiveness of each form of apparatus as applied to the fisheries.

4. The importance of the fisheries by species: Under this head are considered such fisheries as those prosecuted for the cod, the mackerel, the whale, etc.

5. An exhibit of the fisheries by fishing-grounds: These apply more particularly to the food-fish fisheries. The value to the New England fishermen of all the leading fishing-grounds is thoroughly demonstrated by showing the amount of products landed. No feature of this report is of greater importance than that embraced under this heading, since its consideration will show graphically and at a glance the relative importance of these fishing-grounds and will serve as a basis for the consideration of international questions bearing upon the fisheries. It will be seen that the fishing-grounds which are of greatest consequence to our fishermen are those in the open ocean or near our own coast. The grounds in the Gulf of St. Lawrence or in other waters immediately adjacent to Canadian territory are of comparatively minor importance.

6. Special phases of the fisheries, such as the average earnings per ton, per fisherman, per hundred dollars invested capital, etc.: This feature, inasmuch as it exhibits at a glance many of the salient points connected with the fisheries and furnishes a basis for comparing the importance of the various branches of the industry in each county, will doubtless prove of interest.

7. The importance of the bait fishery and the relative effectiveness of certain forms of apparatus in procuring bait.

8. The extent of the important shore industries: These include the branches dependent on the fisheries proper, as sardine and lobster canning, herring smoking, etc.

A brief explanation of certain features of the tables will contribute to a clearer conception of their scope. In the first place, in order to show clearly in one total the yield of different branches of the fisheries, it has been found necessary to reduce to the common unit of a pound certain products that are not usually handled on such a basis in the trade. In reading the tables, therefore, the following key, which covers all cases, should be borne in mind:

Oysters: The weight given is for the edible part (meats and liquor); 7 pounds to a bushel.

Round clams or quahogs (*Venus mercenaria*): Same as oysters; 8 pounds to a bushel.

Long clams or soft clams (*Mya arenaria*): Same as oysters; 10 pounds to a bushel.

Scallops (*Pecten irradians* and *P. magellanicus*): Weight of "eye" or muscle (the edible portion) is given; 3½ pounds to a bushel.

Oil (whale, seal, and fish): 7½ pounds to a gallon.

Idle vessels, boats, apparatus, and shore property are omitted from the statistics.

The boats carried on vessels are not shown separately; their value is included with the outfit of the vessels.

The classification of the fish is into fresh, salted, and smoked. Fish specified as salted are those which leave the vessels or the hands of the fishermen in the various states of preservation by means of salt. The smoked fish shown in the regular tables are only those which are so prepared by the fishermen; the smoking done at canneries and in smokehouses not used by fishermen has been considered to be a manufacturing enterprise and has been included under the head of shore industries. Canned fish are shown only as the products of manufacture and not of fishery. The quantities represent in all cases the weights as sold by the fishermen and, consequently, are considerably less than the weights which the products have when taken from the water. Thus, the fish classified in the tables as salted would, when round, weigh approxi-

mately twice as much as the amount given, and smoked fish lose about two-thirds the weight in the process of curing.

The values of products are in all cases based on the prices paid the fishermen, or the original cost.

The series of special tables for each State, which show in detail (by fisheries and fishing-grounds) the importance of the vessel fisheries, needs some little explanation. By the arrangement giving the extent of the fisheries by fishing-grounds each vessel is credited to all the fisheries in which it was engaged during any portion of the year, together with its tonnage, value, and crew; it is therefore duplicated to that extent, but no duplication of the catch occurs. The following definitions of the more important fisheries recognized will aid in giving a clear understanding of the tables:

Shore fishery: Vessels engaging in this branch are mostly small craft, about 5 to 50 tons, frequenting waters adjacent to the New England shore and catching so-called ground fish, which are sold either fresh or salted.

Market fishery: Vessels credited to this fishery are of medium or large size and take fish on the banks lying to the westward (Georges, Browns, etc.) or off the New England coast. The catch consists mostly of cod, haddock, pollock, hake, and halibut, and is landed in a fresh condition.

Halibut fishery: Vessels incidentally taking small quantities of halibut in the bank, market, and shore fisheries have not been classed under the halibut fishery, which designation has been reserved for vessels making special trips for that species and landing their fares in a fresh condition or fletched and salted. The other species taken while fishing for halibut are properly credited to this fishery.

Mackerel fishery: All vessels taking the common mackerel, with seines, hooks, or gill nets, are shown under this head. Alewives, menhaden, herring, shad, swordfish, and other species taken, in purse seines or by any other means, while catching mackerel are included in this fishery.

The other fisheries are self-explanatory.

In order that no misunderstanding may arise from the use of common or popular names in this paper, it is considered advisable to present in this place the scientific identifications opposite the common names.

Common names.	Scientific names.	Common names.	Scientific names.
Albacore (tunny or horse mackerel).	Albacora thynnus.	Frostfish (or tomcod).	Microgadus tomcodus.
Alewife	Clupea pseudoharengus and C. æstivalis.	Grouper	Epinephelus morio.
Bluefish	Pomatomus saltatrix.	Haddock	Melanogrammus æglefinus.
Bonito	Sarda sarda.	Hake	Phycis chuss and P. tenuis.
Bream (or redfish)	Sebastes marinus.	Halibut	Hippoglossus hippoglossus.
Butter-fish	Stromateus triacanthus.	Herring	Clupea harengus.
Catfish (or wolf-fish)	Anarrhichas lupus.	Hickory shad	Clupea mediocris.
Cod	Gadus morrhua.	Kingfish	Menticirrus nebulosus.
Cunner (chogset or perch).	Ctenolabrus adspersus.	Mackerel	Scomber scombrus.
		Menhaden	Brevoortia tyrannus.
		Pollock	Pollachius virens.
Cusk	Brosmius brosme.	Red snapper	Lutjanus blackfordi.
Eel	Anguilla rostrata.	Salmon	Salmo salar.
Flatfish and flounders.	Paralichthys dentatus, P. oblongus, Pleuronectes maculatus, Pseudoplenronectes americanus, chiefly.	Scup (or porgy)	Stenotomus chrysops.
		Sea bass	Serranus atrarius.
		Shad	Clupea sapidissima.
		Smelt	Osmerus mordax.

Common names.	Scientific names.	Common names.	Scientific names.
Spanish mackerel	Scomberomorus maculatus.	Crabs	Callinectes hastatus and Cancer irrorata, chiefly.
Squeteague (or sea trout).	Cynoscion regale and C. maculatum.	Lobster	Homarus americanus.
Striped bass (or rockfish).	Roccus lineatus.	Shrimp	Crangon vulgaris.
Sturgeon	Acipenser oxyrhynchus.	Clam (soft or long)	Mya arenaria.
Swordfish	Xiphias gladius.	Clam (hard, round, or quahog).	Venus mercenaria.
Tautog	Tautoga onitis.	Oyster	Ostrea virginica.
Whiting (or silver hake).	Merlucius bilinearis.	Scallop	Pecten irradians and P. magellanicus.
Terrapin	Malaclemmys palustris.	Squid	Loligo pealei.

The following tabular statements give a summary, by States, of the New England fisheries in 1889.

The first table shows that 36,536 persons were employed in the industry, of whom 15,122 were engaged in the vessel fisheries, 12,295 in the shore or boat fisheries, and 9,119 in various capacities on shore. In the number of vessel fishermen Massachusetts is much in the lead of all the other States, having 10,851 persons in this class. Maine takes first rank in the shore fisheries and shore industries, giving employment to 6,205 and 5,244 persons, respectively.

The vessels, boats, apparatus, shore property, and cash capital employed in the New England fisheries are next given. The table shows 1,542 vessels, with a tonnage of 79,738.49, valued, with their outfit, at $6,382,006. Massachusetts is credited with more than half of all the fishing vessels of New England, viz, 836, followed by Maine with 408, Connecticut with 214, Rhode Island with 69, and New Hampshire with 15. Of the 11,561 boats, valued at $657,010, used in the shore fisheries, Maine has 5,990, worth $237,469, and Massachusetts has 3,494, valued at $254,033. The apparatus employed in the actual taking of fish and other products was valued at $1,683,525, of which $692,638 represented trawl and hand lines, $442,960 weirs, pound nets, and trap nets, $190,276 pots, $183,220 seines, $104,309 gill nets, and $68,122 minor forms, including bag nets, fyke nets, harpoons, spears, dredges, tongs, rakes, etc. Of the total investment in apparatus of capture, Massachusetts has $1,009,621, Maine $423,564, Rhode Island $119,417, Connecticut $106,682, and New Hampshire $22,291. The capital invested in shore property of various kinds, as wharves, buildings, flake yards, etc., amounted to $5,850,979, of which more than half is to be credited to Massachusetts. The amount of ready money required to properly conduct the fisheries, and known as cash capital or working capital, was $5,523,224, Massachusetts employing $4,284,200. The total investment in vessels, boats, apparatus, shore property, and cash capital amounted to $20,094,794, of which Massachusetts had $13,245,229, Maine $2,889,893, Connecticut $2,826,834, Rhode Island $1,020,178, and New Hampshire $112,660.

The third table shows the quantity and value of each species of fish and other marine products taken in each State. It is seen that, considering the New England States together, the cod is by far the most important species, being valued at $2,539,757, after which come oysters at $1,399,784, lobsters at $833,736, whale products at $828,463, haddock at $738,732, mackerel at $731,424, halibut at $725,756, and menhaden at $428,228. Regarding the quantities of products, menhaden rank first, with 173,632,210 pounds, followed by seaweed, with 149,553,900 pounds; cod, with 97,145,645 pounds; haddock, with 43,473,627 pounds; herring, with 36,316,259 pounds, and lobsters, with

30,449,603 pounds. The largest catch was made by the Massachusetts fishermen, who took 299,217,669 pounds, valued at $5,858,274. Maine ranks second, with 129,559,864 pounds, $2,111,206, followed by Rhode Island, with 127,365,475 pounds, $935,144; Connecticut, with 92,672,464 pounds, $1,557,506, and New Hampshire, with 4,354,568 pounds, $88,511. The combined catch of all the New England States was 653,170,040 pounds, worth $10,550,641.

1.—Table showing the number of persons employed in the fisheries of the New England States in 1889.

States.	Vessel fishermen.	Shore fishermen.	Shoresmen.	Total.
Maine	2,680	6,205	5,244	14,129
New Hampshire	141	194	30	365
Massachusetts	10,851	3,748	2,639	17,238
Rhode Island	388	896	473	1,757
Connecticut	1,062	1,252	733	3,047
Total	15,122	12,295	9,119	36,536

2.—Table showing the apparatus employed and the capital invested in the fisheries of the New England States in 1889.

States.	Vessels.							
	Fishing.				Transporting.			
	No.	Net tonnage.	Value.	Value of outfit.	No.	Net tonnage.	Value.	Value of outfit.
Maine	349	11,476.44	$523,690	$201,487	59	1,660.23	$75,475	$13,100
New Hampshire	15	588.05	32,000	11,099				
Massachusetts	814	57,984.18	3,042,745	1,533,398	22	1,275.12	55,600	7,425
Rhode Island	62	1,402.05	194,325	26,385	7	82.74	2,625	400
Connecticut	200	5,052.60	512,155	134,652	14	217.08	13,395	2,050
Total	1,440	76,503.32	4,304,915	1,907,021	102	3,235.17	147,095	22,975

States.	Apparatus of capture.											
	Boats.		Pound nets, trap nets, and weirs.		Seines.		Gill nets.		Bag nets.		Fyke nets.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Maine	5,990	$237,469	647	$99,917	131	$32,925	5,101	$48,373	280	$11,570	134	$550
New Hampshire	73	4,170	12	860	10	3,800	134	1,570				
Massachusetts	3,494	254,033	224	222,583	293	124,845	4,177	44,212			15	100
Rhode Island	651	62,743	182	81,800	51	13,950	117	7,630			376	2,680
Connecticut	1,353	98,595	113	37,800	55	7,750	62	2,524			440	2,230
Total	11,561	657,010	1,178	442,960	540	183,270	9,591	104,309	280	11,570	965	5,560

States.	Apparatus of capture—continued.									
	Miscellaneous nets.		Lines (value).	Pots.		Harpoons and spears (value).	Dredges, tongs, and rakes (value).	Shore property.	Cash capital.	Total investment.
	No.	Value.		No.	Value.					
Maine	107	$337	$110,051	127,966	$115,717	$887	$3,237	$743,808	$671,300	$2,889,893
New Hampshire			13,171	2,240	2,800	90		32,100	11,000	112,660
Massachusetts	545	1,134	565,516	28,494	40,297	1,379	9,555	3,058,207	4,284,200	13,245,229
Rhode Island			2,625	5,205	6,503	450	3,779	369,759	244,524	1,020,178
Connecticut			1,275	11,553	24,959	469	29,675	1,647,105	312,200	2,826,834
Total	652	1,471	692,638	175,458	190,276	3,275	46,246	5,850,979	5,523,224	20,094,794

3.—Table showing by species the yield of the fisheries of the New England States in 1889.

Species.	Maine.		New Hampshire.		Massachusetts.		Rhode Island.		Connecticut.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Albacore, fresh					74,700	$291				
Alewives, fresh	2,388,225	$13,153	140,400	$3,080	2,032,691	29,173	499,450	$7,518	53,272	$670
Alewives, salted	612,180	8,659			1,251,950	22,282	412,000	8,240		
Alewives, smoked	357,714	8,596					134,800	2,380		
Bluefish, fresh					396,967	33,786	406,875	26,998	516,956	27,383
Bluefish, salted							1,800	90		
Bonito, fresh					194,066	8,157				
Bonito, salted					1,400	88				
Bream, fresh	26,000	270								
Butter-fish, fresh	27,000	445			762,438	23,108	267,050	9,827	42,400	1,064
Catfish, fresh	6,000	120								
Cod, fresh	6,062,472	122,805	1,178,655	23,222	21,105,713	507,866	301,940	9,028	1,529,863	50,018
Cod, salted	11,482,238	314,391	195,000	5,325	55,236,288	1,505,032	63,476	2,070		
Cunners or perch, fresh	104,100	2,623	4,000	200	428,095	18,788	16,000	640	5,000	200
Cusk, fresh	367,600	4,641	33,500	350	431,778	4,932				
Cusk, salted	153,529	1,555			399,405	6,853				
Eels, fresh	103,145	8,735	12,000	1,200	424,708	24,295	249,450	11,878	315,150	24,930
Flatfish and flounders, fresh	829,475	15,815			957,773	20,966	529,750	12,425	633,980	13,005
Frostfish or tomcod, fresh	348,550	3,236			4,873	113			123,500	4,875
Grouper, fresh					16,868	269				
Haddock, fresh	4,768,709	82,371	1,470,025	25,071	34,608,037	592,173	103,120	2,332	205,590	5,599
Haddock, salted	1,520,126	20,269	90,000	1,112	697,380	9,593	10,640	212		
Hake, fresh	2,916,138	27,255	227,295	2,353	5,498,306	55,690			900	15
Hake, salted	5,208,471	61,916	110,000	1,400	855,198	12,242				
Halibut, fresh	490,363	35,955	87,600	6,132	8,913,460	611,654			261,899	20,293
Halibut, salted	600	36			974,930	48,932				
Herring, fresh	17,969,231	76,259	19,800	195	7,920,478	66,222				
Herring, salted	5,209,925	63,673			2,010,900	24,540				
Herring, smoked	3,185,925	99,639								
Hickory shad, fresh					8,640	219				
Kingfish, fresh					4,241	353	9,700	291		
Mackerel, fresh	417,441	36,074	21,800	2,010	2,305,028	190,074	296,612	25,081	33,500	3,311
Mackerel, salted	502,100	51,904	24,600	2,359	4,382,167	394,517	302,000	24,555	16,100	1,539
Menhaden, fresh	10,184,760	28,284	501,000	2,325	2,203,936	12,656	112,580,000	281,450	47,991,714	100,569
Menhaden, salted					170,800	2,944				
Pollock, fresh	2,338,516	22,575	7,000	70	3,092,438	31,901			17,400	365
Pollock, salted	958,722	9,804			1,976,801	23,557	51,520	1,840		
Red snapper, fresh	285,000	7,100			211,156	6,057			520,000	16,800
Salmon, fresh	152,740	34,118			139	66			280	222
Scup, fresh					2,501,165	83,653	6,063,800	91,921	6,800	170
Sea bass, fresh			500	40	814,084	56,795	493,150	13,823	250,201	16,641
Shad, fresh	887,800	18,687	88	3	110,734	3,962	16,650	1,149	195,852	16,580
Shad, salted					123,600	3,406				
Smelt, fresh	1,055,385	74,977	46,000	3,600	10,700	1,098	84,500	4,195	12,800	1,042
Spanish mackerel, fresh					23,461	2,473				
Squeteague, fresh					216,571	10,929	406,214	16,844	206,645	8,298
Striped bass, fresh					24,878	2,669	80,340	7,291	38,770	3,430
Sturgeon, fresh					2,800	132				
Swordfish, fresh	634,435	26,817	25,100	1,159	247,824	11,050	165,990	7,417	146,190	8,285
Swordfish, salted			3,600	180	7,200	334				
Tautog, fresh					646,365	24,365	187,625	7,700	238,640	11,352
Whiting, fresh					114,449	1,399			11,640	174
Miscellaneous fish, fresh			10,000	300	6,567	154	46,250	925	306,860	1,859
Miscellaneous fish, salted					54,200	696				
Refuse fish	448,400	1,755			1,024,400	1,093	1,106,200	1,770		
Shrimp					2,365	860				
Lobsters	25,001,351	574,165	137,175	6,415	3,353,787	148,492	456,000	21,565	1,501,290	83,099
Crabs							4,460	1,125	8,300	300
Terrapin									3,057	1,280
Squid					567,800	4,466				
Oysters					258,867	65,588	1,424,213	271,939	10,401,027	1,055,807
Clams (soft), fresh	2,242,092	73,941	3,000	150	2,243,310	123,947	333,750	32,475	263,600	24,900
Clams (soft), salted	6,181,600	126,820			274,920	13,764				
Quahogs	800	100			135,304	12,549	237,200	25,600	170,896	21,114
Scallops	296,200	18,647			117,232	26,774	22,950	2,550	2,700	230
Oyster shells									7,800,000	6,500
Algæ	12,000,000	6,315			117,963,900	66,084			18,660,000	4,903
Seal and other skins										8,610
Halibut fins					62,000	2,754				
Sounds	103,123	2,579			43,933	1,316				
Tongues	161,564	3,231			251,383	5,026				
Oil, fish	612,020	20,896	6,370	260	2,160,309	77,768				
Oil, whale					6,171,518	488,524			176,701	12,074
Ambergris					37	7,750				
Whalebone					98,268	320,115				
Total	129,559,864	2,111,200	4,354,508	88,511	299,217,669	5,858,274	127,365,475	935,144	92,672,464	1,557,506

3.—Table showing by species the yield of the fisheries of the New England States in 1889—Continued.

SUMMARY.

Species.	Pounds.	Value.	Species.	Pounds.	Value.
Albacore, fresh	74,700	$291	Scup, fresh	8,571,765	$174,744
Alewives, fresh	5,114,038	53,594	Sea bass, fresh	1,557,935	87,299
Alewives, salted	2,276,130	39,181	Shad, fresh	1,211,114	40,381
Alewives, smoked	492,514	10,976	Shad, salted	123,600	3,406
Bluefish, fresh	1,320,798	88,167	Smelt, fresh	1,209,385	84,912
Bluefish, salted	1,800	90	Spanish mackerel, fresh	23,461	2,473
Bonito, fresh	194,066	8,157	Squeteague, fresh	829,430	36,071
Bonito, salted	1,400	88	Striped bass, fresh	143,988	13,390
Bream, fresh	26,000	270	Sturgeon, fresh	2,800	132
Butter-fish, fresh	1,098,888	34,444	Swordfish, fresh	1,219,539	54,728
Catfish, fresh	6,000	120	Swordfish, salted	10,800	514
Cod, fresh	30,168,643	712,939	Tautog, fresh	1,072,630	43,417
Cod, salted	66,977,002	1,826,818	Whiting, fresh	126,089	1,573
Cunners or perch, fresh	557,195	22,451	Miscellaneous fish, fresh	369,677	3,238
Cusk, fresh	832,878	9,923	Miscellaneous fish, salted	54,200	696
Cusk, salted	552,934	8,408	Refuse fish	2,579,000	4,618
Eels, fresh	1,104,453	71,038	Shrimp	2,365	360
Flatfish and flounders, fresh	2,950,978	62,211	Lobsters	30,449,603	833,736
Frostfish or tomcod, fresh	476,923	8,224	Crabs	12,760	1,425
Grouper, fresh	16,868	269	Terrapin	3,057	1,280
Haddock, fresh	41,155,481	707,546	Squid	567,800	4,466
Haddock, salted	2,318,146	31,186	Oysters	12,084,107	1,393,284
Hake, fresh	8,642,639	85,313	Clams (soft), fresh	5,085,752	255,413
Hake, salted	6,173,669	75,558	Clams (soft), salted	6,456,520	140,584
Halibut, fresh	9,765,313	674,034	Quahogs	544,200	59,363
Halibut, salted	975,530	48,968	Scallops	438,181	48,201
Herring, fresh	25,909,509	142,676	Oyster shells	7,800,000	6 500
Herring, salted	7,220,825	88,213	Algæ	149,553,900	77,252
Herring, smoked	3,185,925	99,639	Seal and other skins	.....	8,610
Hickory shad, fresh	8,640	219	Halibut fins	62,000	2,754
Kingfish, fresh	13,941	644	Sounds	147,056	3,895
Mackerel, fresh	3,074,441	256,550	Tongues	412,947	8,257
Mackerel, salted	5,286,967	474,874	Oil, fish	2,778,699	98,924
Menhaden, fresh	173,461,410	425,284	Oil, whale	6,348,219	509,598
Menhaden, salted	170,800	2,944	Ambergris	37	7,750
Pollock, fresh	5,455,354	54,911	Whalebone	98,268	320,115
Pollock, salted	2,987,043	35,201			
Red snapper, fresh	1,016,156	29,957	Total	653,170,040	10,550,641
Salmon, fresh	153,159	34,406			

The question of the nationality of the persons constituting the crews of American fishing vessels is one of marked consequence, in view of the dependence to be placed on the fishery marine of New England in the event of war. The following table gives an accurate idea of the extent to which the citizens of foreign countries were represented in the vessel fisheries of the New England States in 1889. The figures show that Americans constitute 78.30 per cent of the fishermen, while British provincials compose 9.52 per cent and all other nationalities 12.18 per cent.

4.—Table showing the number and nationality of persons employed in the vessel fisheries of the New England States in 1889.

States.	Americans.	British provincials.	All others.	Total.
Maine	2,413	246	21	2,680
New Hampshire	124	11	6	141
Massachusetts	8,002	1,157	1,692	10,851
Rhode Island	386	.....	2	388
Connecticut	916	26	120	1,062
Total	11,841	1,440	1,841	15,122

Fishing Vessels.—Nothing connected with the development of the New England fisheries is more worthy of notice than the improvements recently made in the form and rig of sea-going fishing vessels. The change has been most noticeable, perhaps, in Massachusetts. A few years ago the New England fleet was composed of wide, sharp, shallow schooners, remarkable for having very broad sterns and flat counters. As a

rule they were heavily rigged, and were extremely unsafe in the severe gales to which they were frequently exposed. Many foundered at sea, going down with all their crews, and the loss of life and property was often appalling. The very general belief that this type of vessel was the best for speed led to its general adoption, speed being an important factor in nearly all of the ocean fisheries.

As early, however, as 1882 the U. S. Fish Commission called attention to the faults of this form and rig of fishing vessels, and a change was vigorously urged through the publication of letters in the newspapers printed in fishing towns. Later, in 1886, the Fish Commission schooner *Grampus* was built on new lines. She was a marked innovation on the prevailing ideas concerning the building of fishing vessels, being deeper, and also less broad and flat in her after section. It is to the credit of those interested to say that they soon saw the advantage of having safer and swifter vessels, and since the date last mentioned the most radical changes have occurred in form and rig. The very best talent has been brought to the work of designing fishing craft, and it is safe to assume that at present no other country has a fleet of sailing fishing vessels so swift or so beautiful as those recently turned out from the shipyards of New England, while their seaworthiness has been correspondingly improved. Already the old type is rapidly being superseded by the new, and the change will probably be quite complete in a few years in those branches of fishery where speed and seaworthiness are specially important factors. As a result, not only will there be a marked reduction in loss of life and property by vessels foundering at sea, but the fisheries will be vastly benefited by having vessels so much swifter than those formerly employed.

Mention may appropriately be made of the introduction of the cutter rig on small craft. Until recently the schooner rig has been practically universal north of Cape Cod, but within the past three or four years a few vessels of about 15 or 18 tons have been rigged as cutters or sloops with what is commonly called a double-head rig. These craft have been built on fine lines, and have in some cases been so swift that yachts have been copied after them.

The number and tonnage of the vessels of different rigs employed in the fisheries of each New England State are shown in the next table, the vessels fishing and those transporting being given separately. The special facts disclosed by the table are: (1) the great preponderance of the schooner in the New England States as a whole, and especially in Maine, Massachusetts, and New Hampshire; (2) the employment of ships, barks, and brigs only in the fisheries of Massachusetts; (3) the relatively large number of steam vessels in Connecticut and Rhode Island, and (4) the restriction of the cat rig to Massachusetts and Rhode Island. The proportion of each rig is as follows: Schooners, 78.21 per cent; sloops, 11.09 per cent; steamers, 5.71 per cent; barks, 2.46 per cent; cats, 1.95 per cent; ships, 0.32 per cent, and brigs, 0.26 per cent. The square-rigged vessels are all employed in the whale fishery, the steamers chiefly in the menhaden and oyster industries; sloops have always been in more general favor in Connecticut than elsewhere; the cat-rigged vessels are small, generally only a little more than 6 tons each, and what are commonly called boats. The almost universal adoption of the schooner rig for fishing purposes is well known and emphasizes its fitness for American waters.

5.—Table showing by States and rigs the number and tonnage of vessels employed in the fisheries of the New England States in 1889.

States.	Rigs.	Fishing vessels.		Transporting vessels.	
		No.	Tonnage.	No.	Tonnage.
Maine	Steamers	1	19.28	5	46.73
	Schooners	336	11,351.02	50	1,556.13
	Sloops	12	106.14	4	57.37
	Total	349	11,476.44	59	1,660.23
New Hampshire	Steamers	1	89.03	.....	.....
	Schooners	13	489.42	.....	.....
	Sloops	1	9.00	.....	.....
	Total	15	588.05	.....	.....
Massachusetts	Steamers	4	974.19	.....	.....
	Ships	5	1,753.87	.....	.....
	Barks	38	9,538.77	.....	.....
	Brigs	4	465.60	.....	.....
	Schooners	702	44,715.90	18	1,242.09
	Sloops	40	402.82	3	26.84
	Cats	21	133.03	1	6.19
	Total	814	57,984.18	22	1,275.12
Rhode Island	Steamers	16	751.15	.....	.....
	Schooners	26	474.30	1	21.07
	Sloops	17	158.72	1	7.81
	Cats	3	17.88	5	53.86
	Total	62	1,402.05	7	82.74
Connecticut	Steamers	61	2,183.39	.....	.....
	Schooners	55	1,898.13	5	118.77
	Sloops	84	971.08	9	98.31
	Total	200	5,052.60	14	217.08
New England States	Steamers	83	4,017.64	5	46.73
	Ships	5	1,753.87	.....	.....
	Barks	38	9,538.77	.....	.....
	Brigs	4	465.60	.....	.....
	Schooners	1,132	58,928.77	74	2,938.06
	Sloops	154	1,647.76	17	190.33
	Cats	24	150.91	6	60.05
	Grand total	1,440	76,503.32	102	3,235.17

A further classification of the products of the fisheries is given in the following tabulation. The various fisheries for food-fish are seen to have yielded $6,570,610, the fisheries for oysters, clams, and other mollusks, $1,907,811; the fisheries for lobsters, crabs, and other crustaceans, $837,301; the fishery for menhaden, $395,167; and the fisheries for whales and seals, $837,073.

6.—Table showing the values of the various coast fisheries of the New England States in 1889.

States.	General fisheries.	Oyster and other molluscan fisheries.	Crustacean and reptilian fisheries.	Menhaden fishery.	Mammalian fisheries.	Total.
Maine	$1,298,728	$219,508	$574,165	$18,805	.....	$2,111,206
New Hampshire	79,846	150	6,415	2,100	.....	88,511
Massachusetts	4,639,495	247,038	149,352	6,000	$816,389	5,858,274
Rhode Island	298,440	332,564	22,690	281,450	.....	935,144
Connecticut	256,780	1,108,551	84,679	86,812	20,684	1,557,506
Total	6,573,289	1,907,811	837,301	395,167	837,073	10,550,641

A most important and interesting presentation is made in Table 7, which exhibits by States the quantities and values of fishery products taken by the principal forms of apparatus. Weirs, pound nets, and trap nets take the largest quantities of fish in Maine, but yield the most remunerative returns in Massachusetts, a circumstance due to the difference in the character of the fish in the two States. The catch in seines is greatest in Rhode Island, after which come Connecticut and Maine, but the value of seine-caught fish is much the greatest in Massachusetts. Gill nets take the most fish in Maine, but give the largest money returns in Massachusetts. In Connecticut both the catch and the value of products taken in fyke nets are greater than in any other State. Pots give larger results in Maine than in all the other States combined. Massachusetts easily leads in the products of the hand-line and trawl-line fisheries, showing an excess of nearly $2,500,000 over the aggregate results in all other New England States. The use of miscellaneous apparatus, such as guns, harpoons, dredges, tongs, rakes, dip nets, etc., yields the best results in Massachusetts, though Connecticut is only slightly behind. The catch of whales with harpoons is not considered, this being the reason for the apparent high rank of Connecticut.

Considering the total output for each form of apparatus, it is found that, although the most primitive means of capture, lines took 27.70 per cent of the products and 43.52 per cent of the value; while seines, which yielded nearly as large a percentage of products, viz, 26.73 per cent, took only 8.85 per cent of the value of products. This disparity in value is due to the fact that the most valuable food species are taken on lines, whereas the fish caught in seines are chiefly menhaden, which are sold at relatively low prices for manufacture into oil and fertilizer.

The development of the pound-net, weir, and trap fishery has been quite remarkable in certain sections of New England since the abrogation of the fishery clauses of the Washington treaty. This has been, in a measure, due to the demand for bait caught on our own shores, and has led to the profitable prosecution of the pound-net fishery on the coasts of Maine, Massachusetts, and Rhode Island, in particular. Barnstable Bay and the region east of Portland, Maine, have become noted bait resorts during a large part of each year when herring, squid, and other bait species approach the coast. As will be seen by the tables exhibiting this branch of fishery, the increase in the number of these forms of apparatus has been very marked since 1880.

A remarkable outcome of the pound-net fishery is the profitable utilization of certain products for food purposes that heretofore have been accounted worthless or of little value. Among these may be mentioned the squid, the horse-mackerel or tunny, and the whiting or "Old England hake." It is only recently that the first two species have been considered of any value for food in our markets. The squid is now quite highly prized, and at times the demand is greater than the supply in the markets of the large cities.

The horse mackerel constitutes a cheap, wholesome, and palatable food, and its capture and utilization for this purpose are additionally important in view of the fact that it is one of the most predaceous species in American waters; and, being of large size and generally numerous, it is exceedingly destructive to those species upon which it preys, such as the mackerel, herring, menhaden, etc.

Although the whiting, as it comes from the water, is one of the best-flavored and most nutritious of our food-fishes, the difficulty of keeping it fresh and in good condition when iced has militated against its utilization to a large extent for market

purposes. Often great quantities are taken in pound nets and floating traps; but generally these fish have to be turned out of the nets, only to reënter perhaps on the next tide. Some effort has been made to market at least a portion of the catch, and it is to be hoped that a method will be discovered for utilizing quantities of this species. In view of its abundance and cheapness it seems pertinent to suggest the possibility of its profitable utilization by canning or smoking. Its delicate flavor should make it an excellent article of food when canned, or, if lightly salted and prepared like kippered herring and finnan haddies, a demand might be created which would consume great quantities of what is now essentially a waste product.

Another noteworthy result of the abolition of the fishery clauses of the Washington treaty and the attempt of American fishermen to secure supplies of bait on the New England coast, is the catch of herring at night on the coast of Maine by means of the purse seine; for a number of years it has been a common occurrence to catch mackerel at night in this manner, and on some occasions herring have been thus taken by mistaking them for mackerel. The recent demand for bait led to the attempt being made at and near Boothbay to carry on somewhat of a systematic purse-seine fishery for herring at night. The results have been gratifying, on the whole, and there is fair promise of the continuance of the enterprise.

Mention may be made here of the fact that at certain seasons, especially in spring and summer, the herring occurring offshore in the Gulf of Maine are in prime condition for pickling. If these are taken and properly prepared, they will readily sell at a high price.

7.—Table showing the quantities, values, and percentages of fishery products taken in each kind of apparatus in the New England States in 1889.

Apparatus.	Maine.		New Hampshire.		Massachusetts.		Rhode Island.		Connecticut.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Weirs, pound nets and trap nets	21,921,538	$231,326	138,788	$3,303	14,633,315	$328,386	9,683,879	$171,771	7,556,665	$43,288
Seines	*12,411,693	*132,890	503,800	5,289	7,099,120	405,935	113,162,525	297,115	41,426,634	92,717
Gill nets	9,608,708	120,802	61,960	940	5,163,153	139,278	292,820	18,924	116,880	6,714
Fyke nets	111,000	1,380	.....	.....	44,655	1,400	114,250	3,045	455,250	8,759
Pots	25,083,426	581,416	137,175	6,415	3,657,251	163,956	570,750	27,405	1,834,740	108,432
Trawl and hand lines	37,055,071	758,198	3,462,775	69,615	135,387,320	3,533,965	1,352,688	75,778	3,649,824	153,593
Miscellaneous	23,368,428	285,194	50,070	2,949	133,232,805	1,285,354	2,188,563	341,106	37,632,471	1,144,003
Total	129,559,864	2,111,206	4,354,568	88,511	299,217,669	5,858,274	127,365,475	935,144	92,672,464	1,557,506

Apparatus.	Total.		Percentage.	
	Pounds.	Value.	Pounds.	Value.
Weirs, pound nets, and trap nets	53,934,185	$778,074	8.26	7.37
Seines	174,603,772	933,946	26.73	8.85
Gill nets	15,243,521	286,608	2.33	2.72
Fyke nets	725,155	14,584	.11	.14
Pots	31,283,342	887,624	4.79	8.41
Trawl and hand lines	180,907,678	4,591,149	27.70	43.52
Miscellaneous	196,472,387	3,058,606	30.08	28.99
Total	653,170,040	10,550,641	100.00	100.00

*Including bag nets.

The following table, showing the actual and relative importance of the vessel and shore fisheries, presents some interesting facts. In Maine the vessel fishery employed 29 per cent of the fishermen, 63 per cent of the investment in fishing property, and yielded 33 per cent of the value of products. In New Hampshire this branch of fishery furnished occupation for 42 per cent of the fishermen, 86 per cent of the fishery investments, and produced 63 per cent of the catch. Seventy-four per cent of the fishermen of Massachusetts were employed on vessels; 90 per cent of the value of fishing property was invested in vessels, which landed 82 per cent of the fishery products. Rhode Island had 30 per cent of her fishermen and 59 per cent of her fishing investments in the vessel fishery, which yielded 43 per cent of the products. The returns for Connecticut show that this branch of fishery employed 45 per cent of the fishermen, 80 per cent of the invested capital, and produced 71 per cent of the value of the catch. Massachusetts had the greatest percentage of fishermen in vessel fisheries, and Maine the greatest percentage in shore fisheries; Massachusetts had the largest proportion of capital in vessels, and Rhode Island the largest ratio in shore fishery, boats, and apparatus; Massachusetts vessel fisheries and Maine shore fisheries took the greatest percentage of products. The men and vessels employed in transporting fishing products are not included in the discussion or table.

8.—Table showing by States the actual and relative importance of the vessel and shore fisheries of New England in 1889.

States.	Fishermen.				Investment.				Products.			
	No.		Percentage.		Value.		Percentage.		Value.		Percentage.	
	Vessel.	Shore.	Vessel.	Shore.	Vessel.	Shore.	Vessel.	Shore.	Vessel.	Shore.	Vessel.	Shore.
Maine	2,515	6,205	29	71	$871,115	$515,095	63	37	$690,967	$1,420,239	33	67
New Hampshire	141	194	42	58	59,764	9,796	86	14	56,018	32,493	63	37
Massachusetts	10,760	3,748	74	26	5,272,577	567,220	90	10	4,778,185	1,080,089	82	18
Rhode Island	376	896	30	70	236,435	166,445	59	41	398,310	536,834	43	57
Connecticut	1,030	1,252	45	55	681,476	170,608	80	20	1,107,087	450,419	71	29
Total	14,822	12,295	55	45	7,121,367	1,429,164	83	17	7,030,567	3,520,074	67	33

Table 9, which is next presented, shows by fisheries the extent and relative value of the vessel fisheries in each of the New England States. With a view to exhibit the full comparative importance of the various fisheries, each vessel is credited to all the fisheries in which it was engaged during any portion of the year, together with its tonnage, value, and crew. It is therefore duplicated to that extent. The value of the catch in each fishery, however, is not duplicated, and taken in the aggregate will give the total value of the vessel fisheries of each State, with the exception of sounds, tongues, and fish oil.

9.—Table showing the relative importance of each of the vessel fisheries of the New England States in 1889.

Fisheries.	States.	No. of vessels.	Net tonnage.	Value of vessels.	No. of men.	Value of catch.
Bank cod	Maine	48	4,257.12	$214,900	773	$190,423
	Massachusetts	306	23,702.69	1,261,026	4,295	1,532,767
	Total	354	27,959.81	1,475,926	5,068	1,723,190
Halibut	Maine	4	334.09	21,500	52	15,992
	New Hampshire	1	68.93	2,800	12	6,132
	Massachusetts	53	4,466.84	286,834	804	536,176
	Total	58	4,869.86	311,134	868	558,300
Mackerel	Maine	80	7,096.01	311,490	584	66,376
	New Hampshire	7	243.96	14,600	65	4,129
	Massachusetts	297	13,318.82	700,780	2,976	473,755
	Rhode Island	26	291.63	22,325	97	18,136
	Connecticut	9	160.40	11,650	27	3,894
	Total	419	21,110.82	1,060,845	3,749	566,290
Market	Maine	18	1,210.62	64,900	244	66,594
	New Hampshire	1	68.93	2,800	12	1,800
	Massachusetts	201	13,440.18	827,175	2,887	1,119,699
	Connecticut	27	1,022.44	62,600	197	104,072
	Total	247	15,742.17	957,475	3,340	1,292,165
Shore	Maine	217	4,755.82	185,090	1,225	228,386
	New Hampshire	11	337.06	16,400	96	39,613
	Massachusetts	180	3,407.53	172,775	999	177,188
	Rhode Island	21	249.81	21,200	84	10,967
	Connecticut	37	481.84	31,330	111	26,360
	Total	466	9,232.06	426,795	2,515	482,514
Whale and seal	Massachusetts	68	14,303.55	663,400	1,918	816,389
	Connecticut	4	402.33	15,000	69	20,684
	Total	72	14,705.88	678,400	1,987	837,073
Herring	Maine	107	1,908.01	69,000	455	39,507
	Massachusetts	34	742.07	35,550	174	15,060
	Total	141	2,650.08	104,550	629	54,567
Menhaden	Maine	20	641.52	23,110	163	18,805
	New Hampshire	1	89.63	6,000	16	2,100
	Massachusetts	1	26.97	6,000	13	6,000
	Rhode Island	16	890.05	137,000	219	281,450
	Connecticut	6	451.80	61,500	125	86,812
	Total	44	2,099.97	233,610	536	395,167
Swordfish	Maine	25	700.51	34,050	157	26,817
	New Hampshire	1	30.93	1,600	9	1,339
	Massachusetts	30	440.53	28,050	139	9,636
	Rhode Island	16	232.43	24,525	64	7,417
	Connecticut	11	186.86	13,150	39	8,101
	Total	83	1,591.26	101,375	408	53,310
Molluscan	Maine	7	97.08	2,875	30	3,532
	Massachusetts	12	75.25	4,975	25	3,569
	Rhode Island	17	180.17	26,350	44	79,745
	Connecticut	113	2,326.89	319,150	419	831,100
	Total	149	2,679.39	353,350	518	917,946
Lobster	Maine	29	370.64	14,825	102	17,432
	New Hampshire	1	19.41	1,300	6	645
	Massachusetts	10	151.75	9,000	35	3,836
	Rhode Island	1	5.45	500	2	595
	Connecticut	22	261.18	18,915	62	26,064
	Total	63	808.43	44,540	207	48,572

Two tables are next introduced which give for the vessel and shore fisheries, respectively, certain averages and percentages which are instructive. They show the great differences between the various States in certain elements of these industries.

In the size of vessels, it is seen that the average is 32.88 tons in Maine, 39.20 tons in New Hampshire, 71.23 tons in Massachusetts, 22.61 tons in Rhode Island, and 25.34 tons in Connecticut. The general average is 53.18 tons. The average value of vessels is least in Maine, viz, $1,500, and greatest in Massachusetts, viz, $3,738, the average for New England being $2,993. The average value per net ton is also least in Maine and greatest in Rhode Island, the latter State having a considerable fleet of expensive steam vessels. Massachusetts vessels have a less value per ton than those of Connecticut and New Hampshire, Connecticut having a number of steamers which bring up the average and New Hampshire possessing a small fleet of relatively valuable vessels. The general average value per ton is $57. In the items of apparatus and outfit, Massachusetts also takes the lead, with an average of $2,739, followed by New Hampshire, Maine, Connecticut, and Rhode Island, the last State being credited with $679, while the average for all the States is $1,958. The average number of men carried on vessels is 13 in Massachusetts, 9 in New Hampshire, 7 in Maine, 6 in Rhode Island, and 5 in Connecticut, the general average being 10. Connecticut and Rhode Island easily take the first positions in the average value of catch for each man constituting the crews, owing to the use of steam in the oyster and menhaden fisheries; Massachusetts ranks third, followed by New Hampshire and Maine. Rhode Island takes precedence in the matter of average gross stock per vessel, with $6,424, after which are Massachusetts with $5,867, Connecticut with $5,591, New Hampshire with $3,734, and Maine with $1,979, the average for all States being $4,888. For each net ton the vessels of Rhode Island and Connecticut take products to the value of $284 and $221, respectively, while the average for all the other States is less than $100. For each $100 invested in the vessel fishery, Rhode Island and Connecticut vessels stock $168 and $163, respectively, taking similar precedence over the remaining States.

Consideration of the figures showing the percentages of value of products for each form of apparatus employed in the vessel fisheries discloses some important facts illustrative of the different interests involved in the fisheries of the several States. The seine is more important than any other apparatus in Rhode Island, in which State 71 per cent of the stock of the vessels is obtained by this means, while in each of the other States the seine is to be credited with only 10 per cent or less of the value of products. In New Hampshire, Maine, and Massachusetts hand lines and trawl lines yield the largest returns, the figures for these States being 86 per cent, 73 per cent, and 72 per cent, respectively. In Connecticut only 12 per cent of the value of products is obtained with lines, and in Rhode Island only 7 per cent. Gill nets and pots are of greater comparative value in the vessel fisheries of Maine than elsewhere, although their general importance is slight. Miscellaneous forms of apparatus, as fyke nets, dredges, rakes, harpoons, guns, etc., are much more valuable in Connecticut than elsewhere, as much as 78 per cent of the value of the vessel catch in that State being taken in this way. Concerning New England as a whole, it is seen that 59 per cent of the yield of the vessel fisheries is taken with lines, 12 per cent with seines, 1 per cent each with gill nets and pots, and 27 per cent with miscellaneous devices.

In the shore fisheries the average value of fishery products taken by each man is greatest in Rhode Island and least in New Hampshire, the general average being $286, a sum considerably less than in the vessel fisheries. For each $100 invested in boats, $536 worth of products are obtained, Rhode Island, New Hampshire, and Maine having more than the general average, and Massachusetts and Connecticut less. The

average value of catch for each $100 devoted to apparatus is greatest in Connecticut and least in Massachusetts, the average for the region being $456.

In the shore fisheries of Maine, pots yield 40 per cent of the gross income and are by far the most important form of apparatus; in New Hampshire they are credited with 18 per cent of the value of fishery products, in Massachusetts 15 per cent, in Connecticut 16 per cent, and in Rhode Island 5 per cent, the average for New England being 24 per cent. Pound nets, trap nets, and weirs are relatively more important in Rhode Island than in any other State, 32 per cent of the value of shore fisheries resulting from their use; Massachusetts closely follows with 30 per cent, while Maine, New Hampshire, and Connecticut have 16, 10, and 10 per cent, respectively, the total for the region being less than for pots, or 22 per cent. The comparative value of lines is by far the greatest in New Hampshire, viz, 66 per cent, after which come Maine with 18 per cent, Massachusetts with 10 per cent, Rhode Island with 9 per cent, and Connecticut with 5 per cent. The difference between the shore and vessel fisheries in this respect is very noticeable. Gill nets, of little relative importance in any State, are most valuable in Massachusetts. Seines and bag nets are chiefly valuable in Maine and are generally less important than gill nets. The miscellaneous apparatus already specified yields 67 per cent of the income of fishermen in Connecticut, 48 per cent in Rhode Island, and 34 per cent in Massachusetts, the general average of 33 per cent being much greater than for any other single form of apparatus separately referred to.

10.—Table showing certain averages and percentages for the vessels employed in the fisheries of the New England States in 1889.

States.	Average tonnage of vessels.	Average value of vessels.	Average value per net ton.	Average value of apparatus and outfit.	Average number of crew.	Average value of catch per man.	Average value of catch per vessel.	Average value of catch per ton.	Average value of catch per each $100 invested in vessels, outfit, and apparatus.	Percentage of value of catch in each form of apparatus.				
										Lines.	Seines.	Gill nets.	Pots.	Miscellaneous apparatus.
Maine	32.88	$1,500	$46	$995	7	$275	$1,979	$60	$71	72.83	9.81	7.88	2.61	6.87
New Hampshire	39.20	2,133	54	1,831	9	397	3,734	95	94	86.27	9.23	.50	1.15	2.85
Massachusetts	71.23	3,738	53	2,739	13	444	5,867	82	91	71.67	8.15	.90	.08	19.20
Rhode Island	22.61	3,118	138	679	6	1,059	6,424	284	168	7.29	70.66	.02	.15	21.88
Connecticut	25.34	2,582	102	853	5	1,114	5,591	221	163	12.01	7.95	.....	2.35	77.69
Total	53.18	2,993	57	1,958	10	475	4,888	92	99	58.86	11.83	1.39	.70	27.22

11.—Table showing certain averages and percentages for the shore fisheries of the New England States in 1889.

States.	Average value of catch per man.	Average value of catch per each $100 invested in boats.	Average value of catch per each $100 invested in apparatus.	Percentage of value of catch in each form of apparatus.					
				Pound nets, trap nets, and weirs.	Pots.	Lines.	Gill nets.	Haul seines and bag nets.	Miscellaneous apparatus.
Maine	$229	$598	$508	16.40	39.94	18.07	4.70	4.62	16.27
New Hampshire	167	774	580	10.17	17.75	65.52	2.03	.37	4.16
Massachusetts	288	425	345	30.40	14.83	10.11	8.89	1.55	34.22
Rhode Island	599	856	517	32.00	4.99	8.71	3.51	2.92	47.87
Connecticut	359	457	626	9.61	15.86	4.59	1.49	1.04	67.41
Total	286	536	456	22.15	23.58	12.90	5.37	2.92	33.08

Table 12 gives by States the relative value of fifteen important edible fishery products. Maine surpasses the other States in the value of hake, herring, smelt, swordfish, clams, and lobsters, and Massachusetts leads in the value of alewives, bluefish, cod, haddock, halibut, mackerel, and pollock. Rhode Island ranks first in the item of menhaden and Connecticut in oysters.

12.—Table showing for each of fifteen important species the percentage of value in each New England State to the total value of the catch in New England.

Species.	Maine.	New Hampshire.	Massachusetts.	Rhode Island.	Connecticut.
Alewives	29.31	2.97	49.59	17.48	.65
Bluefish			38.28	30.69	31.03
Cod	17.21	1.12	79.26	.44	1.97
Haddock	13.89	3.55	81.46	.34	.76
Hake	55.43	2.33	42.23		.01
Halibut	4.98	.85	91.37		2.80
Herring	72.48	.06	27.46		
Mackerel	12.03	.60	79.92	6.79	.66
Menhaden	6.61	.54	3.64	65.72	23.49
Pollock	35.93	.08	61 54	2.04	.41
Smelt	88.30	4.24	1.29	4.94	1.23
Swordfish	48.54	2.42	20.61	13.43	15.00
Clams	50.70	.04	34.77	8.20	6.29
Oysters			4.70	19.52	75.78
Lobsters	68.86	.77	17.81	2.59	9.97

The relative extent of the fisheries of New England in 1880 and 1889 is brought out in Tables 13, 14, and 15. The figures given for 1880 are those obtained for the census and represent, for the most part, the statistical condition of the fisheries in 1879. These tables, therefore, indicate the changes during the past decade.

It is seen that there has been a net decrease in the number of fishermen amounting to 2,421, and a net increase in the number of shoresmen aggregating 1,914, leaving a total net decrease in persons employed of 507. Maine is the only State in which there has been a general increase in the persons engaged in the fisheries, although Connecticut shows a substantial gain in the number of shoresmen. In the former State the percentage of increase was 27.62, while in New Hampshire, Massachusetts, Rhode Island, and Connecticut the percentage of decrease was 11.83, 14.31, 23.94, and 2.68, respectively, the net decrease being 1.37 per cent.

In the items constituting investment there have been numerous changes during the decade. The vessels employed in the fisheries have been reduced in number by 445, with a tonnage of 30,609.43, and a value of $75,471, exclusive of outfit and apparatus; this decrease is observed in every State, although Maine, Rhode Island, and Connecticut exhibit an increased investment in vessels, indicating the employment of more fishing craft of superior types, notably steamers, in the two latter States. The decrease in Massachusetts is chiefly in whalers. In the number of boats there has been a net decline of 3,226, valued at $82,960, although both Maine and Connecticut show a small increase in number. The amount of investment in apparatus and outfit has naturally decreased with the decline in the number of fishermen, vessels, and boats. The year 1880 presents an excess over 1889 amounting to $1,426,600; Rhode Island alone has advanced in this respect. Shore property and cash capital show a net increase of $1,776,868, participated in by Massachusetts, Rhode Island, and Connecticut, the last State showing the greatest advance. In the total investment in fishing property and appliances, there has been a net increase of $191,837, or 0.96 per cent, Rhode Island and Connecticut alone sharing in this advance.

The most interesting comparison is that which relates to the results of the fisheries. It is found that the general food-fish fisheries have experienced a serious decline in the three most northern States of the section, and that in the two southern States there has been a satisfactory improvement, the net decrease being $1,843,517; this decrease may be accounted for by the scarcity of mackerel. A return of this species in its former abundance would place additional products on the market having a value much greater than the difference noted. The fisheries for clams, oysters, scallops, and other mollusks have advanced in every State except New Hampshire, and exhibit a total net excess over 1880 of $944,752. The value of lobsters and other crustaceans was $312,346 greater in 1889 than in 1880, the principal part of this sum representing the lobster fishery of Maine. The menhaden fishery in New England has increased $30,202 since 1880, notwithstanding the fact that much of the capital formerly devoted to the industry in Massachusetts and Connecticut has been diverted into other channels. In Rhode Island, which is the most important center of the menhaden fishery, the increase in the value of fish caught has been $109,715. As is well known, the whale and seal fisheries are much less extensively prosecuted than in 1880, and the large decrease of $1,396,163 is not surprising. Considering the aggregate results of the fisheries, the table shows that the net decrease in the value of products was $1,952,380, or 15.62 per cent. Connecticut has undergone the largest increase, amounting to 66.89 per cent, and New Hampshire shows the largest decrease, 48.13 per cent.

13.—Comparative table showing the number of persons employed in the fisheries of the New England States in 1880 and 1889.

State.	Fishermen.		Shoresmen.		Total.		Increase or decrease in 1889.	Percentage of increase or decrease in 1889.
	1880.	1889.	1880.	1889.	1880.	1889.		
Maine	8,110	8,885	2,961	5,244	11,071	14,129	+3,058	+27.62
New Hampshire	376	335	38	30	414	365	— 49	— 11.83
Massachusetts	17,165	14,599	2,952	2,639	20,117	17,238	—2,879	—14.31
Rhode Island	1,602	1,284	708	473	2,310	1,757	— 553	—23.94
Connecticut	2,585	2,314	546	733	3,131	3,047	— 84	— 2.68
Total	29,838	27,417	7,205	9,119	37,043	36,536	— 507	— 1.37

14.—Comparative table showing the number and value of vessels, boats, etc., employed in the fisheries of the New England States in 1880 and 1889.

States.	Vessels.						Boats.			
	1880.			1889.			1880.		1889.	
	No.	Net tonnage.	Value.	No.	Net tonnage.	Value.	No.	Value.	No.	Value.
Maine	574	16,529.66	$598,892	408	13,136.67	$599,165	5,920	$245,624	5,990	$237,469
New Hampshire	23	1,019.05	51,500	15	588.05	32,000	211	7,780	73	4,170
Massachusetts	1,007	81,080.49	3,171,189	836	59,259.30	3,098,345	6,749	351,736	3,494	254,033
Rhode Island	92	2,502.77	191,850	69	1,484.79	196,950	734	61,245	651	62,743
Connecticut	291	9,215.95	514,050	214	5,269.68	525,550	1,173	73,585	1,353	98,595
Total	1,987	110,347.92	4,527,481	1,542	79,738.49	4,452,010	14,787	739,970	11,561	657,010

14.—Comparative table showing the number and value of vessels, boats, etc., employed in the fisheries of the New England States in 1880 and 1889—Continued.

States.	Value of apparatus and outfits.		Cash capital and shore property.		Total capital invested.		Increase or decrease in 1889.	Percentage of increase or decrease in 1889.
	1880.	1889.	1880.	1889.	1880.	1889.		
Maine	$934,593	$638,151	$1,562,235	$1,415,108	$3,341,344	$2,889,893	— $451,451	—13.51
New Hampshire	60,385	33,390	89,800	43,100	209,465	112,660	— 96,805	—46.22
Massachusetts	3,528,925	2,550,444	7,282,600	7,342,407	14,334,450	13,245,229	—1,089,221	— 7.60
Rhode Island	138,733	146,202	204,850	614,283	596,678	1,020,178	+ 423,500	+70.98
Connecticut*	375,535	243,384	457,850	1,959,305	1,421,020	2,826,834	+1,405,814	+98.93
Total	5,038,171	3,611,571	9,597,335	11,374,203	19,902,957	20,094,794	+ 191,837	+ .96

15.—Comparative table showing the values of the fisheries of the New England States in 1880 and 1889.

States.	General fisheries.		Molluscan fisheries.		Crustacean and reptilian fisheries.		Menhaden fishery.		Mammalian fisheries.	
	1880.	1889.	1880.	1889.	1880.	1889.	1880.	1889.	1880.	1889.
Maine	$2,313,655	$1,298,728	$112,706	$219,508	$316,210	$574,165	.....	$18,805	.....	.....
New Hampshire	154,154	79,846	8,980	150	7,500	6,415	.....	2,100	.....	.....
Massachusetts	5,547,910	4,639,495	133,784	247,038	158,229	149,352	*$30,500	6,000	$2,089,337	$816,389
Rhode Island	226,244	298,440	282,964	332,564	15,871	22,690	*171,735	281,450	.....	.....
Connecticut	174,843	256,780	424,625	1,108,551	27,145	84,679	*162,730	86,812	143,899	20,684
Total	8,416,806	6,573,289	963,059	1,907,811	524,955	837,301	364,965	395,167	2,233,236	837,073

States.	Total.		Increase or decrease in 1889.	Percentage of increase or decrease in 1889.
	1880.	1889.		
Maine	$2,742,571	$2,111,206	— $631,365	— 23.02
New Hampshire	170,634	88,511	— 82,123	— 48.13
Massachusetts	7,959,760	5,858,274	— 2,101,486	— 26.40
Rhode Island	696,814	935,144	+ 238,330	+ 34.20
Connecticut	933,242	1,557,506	+ 624,264	+ 66.89
Total	12,503,021	10,550,641	— 1,952,380	— 15.62

* Estimated.

The menhaden fishery is remarkable for the opposition which it has met with in recent years, and which has never been equaled in the case of any other ocean fishery of the United States. The effective methods for the capture of fish which have been employed in catching menhaden have led many otherwise well-informed persons, and many of the boat fishermen along the coast, whose operations are carried on upon a very limited scale, to believe that these methods are harmful and destructive, and calculated not only to materially decrease the abundance of menhaden, but also to seriously interfere with the food-fish fisheries. For this reason, a very decided and active prejudice has developed and legislation has been sought both in State legislatures and Congress to restrict the operations of menhaden fishermen with the alleged object of benefiting other fisheries. The lack of space renders it impracticable to enter into a discussion here of this matter with sufficient detail to elucidate all sides of the subject; but it seems very remarkable that an industry of such importance should not only be deprived of the encouragement generally accorded to other fisheries, but that its continuance is jeopardized through opposition.

The extensive industry dependent on the menhaden fishery is shown in Table 16.

In Maine the figures represent the importance of the business in the second year of the reappearance of menhaden in the coast waters of that State, after an absence of about ten years, and indicate a revival of the extensive industry which formerly existed there. Already the State is only slightly behind Connecticut in the amount of capital invested and the quantity of fish utilized, and the continued annual occurrence of large bodies of menhaden in this region will doubtless contribute to the rapid development of the business, if only reasonable restrictions are placed on the fishery.

Rhode Island has much more important menhaden interests than both Maine and Connecticut combined. The returns for this State show $452,925 invested capital, 177,133,333 menhaden utilized, 1,782,145 gallons of oil manufactured, and 7,397 tons of scrap made, the two latter articles having a value of $427,757, or more than two-thirds the amount accruing from the industry in New England.

16.—Table showing the extent of the menhaden industry of the New England States in 1889.

States.	Steam vessels employed.				Sail vessels employed.				Total vessels employed.			
	No.	Net tonnage.	Value.	Value of outfit.	No.	Net tonnage.	Value.	Value of outfit.	No.	Net tonnage.	Value.	Value of outfit.
Maine	4	218.22	$32,000	$8,800	13	398.10	$15,950	$13,065	17	616.32	$47,950	$21,865
Rhode Island	11	758.45	133,000	27,000	7	146.93	5,325	3,600	18	905.38	138,325	30,600
Connecticut	6	451.80	61,500	10,000	4	41.49	1,835	320	10	493.29	63,335	10,320
Total	21	1,428.47	226,500	45,800	24	586.52	23,110	16,985	45	2,014.99	249,610	62,785

States.	Factories in operation.			Total capital invested in the industry.	Number of persons employed.		Menhaden handled.		Oil manufactured.		Scrap prepared.		Total value of manufactured products.
	No.	Value.	Cash capital.		Factorymen.	Fishermen.	No.	Price paid.	Gallons.	Value.	Tons.	Value.	
Maine	3	$22,200	$20,000	$112,015	104	195	26,057,583	$31,269	282,465	$62,409	2,305	24,735	$87,144
Rhode Island	4	208,000	76,000	452,925	358	215	177,133,333	265,700	1,782,145	320,743	7,397	107,014	427,757
Connecticut	4	83,200	25,500	182,355	82	133	37,360,700	52,927	233,228	53,110	2,893	45,956	99,066
Total	11	313,400	121,500	747,295	544	543	240,551,616	349,896	2,297,838	436,262	12,595	177,705	613,967

Frozen-herring trade.—In the "Statistical Review of the Coast Fisheries of the United States," covering the years 1887 and 1888, brief allusion was made to the frozen-herring trade, an industry which is now almost exclusively under the control of New England fishery capitalists. The importance of this trade to the fishing interests of the British Provinces and the United States is very great. The former are benefited by having the opportunity of selling products at remunerative prices, which otherwise could not find a satisfactory market in the winter season, while the vessels and men that are engaged in other branches of the American fisheries during the summer find profitable employment in winter in obtaining and marketing cargoes of frozen herring. These products are used for food and bait. The herring is a cheap and nutritious food. It is especially valuable when it can be obtained by the consumer in a perfectly fresh state, as is the case when it is marketed in a frozen condition. The value of herring for bait purposes is so well known as to obviate the necessity of more than a mere mention of it. It may not be so well understood, however, that adequate supplies of fresh herring could not be so easily and so cheaply obtained in any other manner.

Allusion should be made to the uncertainties which render this trade one of the most hazardous, from a financial standpoint, in which men ordinarily engage. The two

important factors, generally speaking, are fish and weather. Herring may be exceedingly abundant and cheap at the fishing stations, but if the weather is mild it is impossible to freeze a cargo if the natural temperature at the station is depended upon. On the other hand, the conditions of freezing may be all that could be desired, but the fish do not appear, and days, weeks, and months are passed in waiting. It has not been uncommon for vessels to be compelled to return without cargoes. There are uncertainties, too, even when fish have been obtained in good condition. An overstocked market brings the price down to a point where loss can not be avoided, and disadvantage to the fisherman may often result from a continuance of warm weather immediately after the sale of a cargo has begun, since the sale generally continues for several days or weeks, and mild weather causes the frozen herring to "slack up" and become unfit for market.

It is a matter for congratulation that recently success has been met with in freezing herring on board of vessels by artificial methods. As long ago as 1878, when Prof. Baird established his headquarters at Gloucester, Massachusetts, he suggested the importance of applying artificial methods to the freezing of herring for bait. Recently the system has been adopted with marked success. This eliminates many uncertainties attending the business and the method will doubtless be largely applied in the near future.

The supply is obtained, as will be seen in the tables, from Newfoundland and New Brunswick. During some seasons a few cargoes are received from Nova Scotia, but it is now very exceptional for vessels to visit the latter province for frozen herring. Formerly vessels from Massachusetts engaged in the trade with Newfoundland and New Brunswick, nearly an equal number visiting each province. Recently, however, there has been a marked change in this respect. The New Brunswick herring trade in winter is, with few exceptions, carried on by vessels belonging in Maine, while vessels from Massachusetts engage almost exclusively in voyages to Newfoundland. This is due in some measure to the fact that the Maine vessels employed in this trade are of comparatively small tonnage, and not so well fitted as those from Massachusetts to make long ocean voyages in midwinter. The proximity of the Maine ports to the fishing-grounds in New Brunswick also has its influence.

Both for market and bait purposes the Newfoundland herring are preferred by Americans and bring the highest price. This accounts chiefly for the fact that the largest and finest fishing schooners sailing from Massachusetts engage in the Newfoundland herring trade.

In 1889, 26 vessels, with a tonnage of 1,140.70, were engaged in the New Brunswick frozen-herring trade, and brought to the markets of the United States 6,289,000 herring, valued at $39,622. Forty-six vessels, of 4,267.98 aggregate tonnage, found employment in the frozen-herring trade with Newfoundland and brought to our markets 16,235,000 herring, valued at $239,675.

In addition to the herring brought to the United States on American vessels, a considerable quantity was imported on vessels sailing under the British flag. Table 18 shows that 2,593,000 pounds, valued at $33,939, were thus sold in our markets during 1889. This is, however, in addition to large quantities of frozen herring imported from the provinces on steamers. Many herring are shipped in this way from New Brunswick on the regular line of steamers plying between St. John and New England ports.

17.—Table showing the extent of the frozen-herring trade of the New England States in 1889.

Ports.*	Vessels.			Herring carried.	
	No.	Net tonnage.	Value.	No.	Value.
Trade with New Brunswick:					
Calais, Me	1	24.55	$800	140,000	$882
Eastport, Me	8	287.46	11,800	2,329,000	14,673
Lubec, Me	2	42.46	1,650	295,000	1,859
Ellsworth, Me	2	148.06	3,100	525,000	3,308
Deer Isle, Me	1	50.51	1,250	100,000	630
Belfast, Me	1	42.73	1,000	230,000	1,449
North Haven, Me	1	36.16	1,000	190,000	1,197
Portland, Me	1	53.80	1,800	330 000	2,079
Total for Maine ports	17	685.73	22,400	4,.39,000	26,077
Gloucester, Mass	8	400.67	13,913	1,924,000	12,121
Boston, Mass	1	54.30	800	226,000	1,424
Dennis, Mass	.....	.....	.....	.....	.....
Provincetown, Mass	.....	.....	.....	.....	.....
Total for Massachusetts ports	9	454.97	14,713	2,150,000	13,545
Grand total	26	1,140.70	37,113	6,289,000	39,622
Trade with Newfoundland:					
Portland, Me	2	194.66	13,000	770,000	7,700
Gloucester, Mass	37	3,458.08	216,546	13,275,000	191,125
Boston, Mass	†3	233.38	13,800	1,030,000	15,450
Dennis, Mass	1	99.99	7,000	400,000	6,000
Provincetown, Mass	3	281.87	11,500	760,000	11,400
Total for Massachusetts ports	44	4,073.32	248,846	15,465,000	231,975
Grand total	46	4,267.98	261,846	16,235,000	239,675
Total trade:					
Calais, Me	1	24.55	800	140,000	882
Eastport, Me	8	287.46	11,800	2,329,000	14,673
Lubec, Me	2	42.46	1,650	295,000	1,859
Ellsworth, Me	2	148.06	3,100	525,000	3,308
Deer Isle, Me	1	50.51	1,250	100,000	630
Belfast, Me	1	42.73	1,000	230,000	1,449
North Haven, Me	1	36.16	1,000	190,000	1,197
Portland, Me	3	248.46	14,800	1,100,000	9,779
Total for Maine ports	19	880.39	35,400	4,909,000	33,777
Gloucester, Mass	45	3,858.75	230,459	15,199,000	211,246
Boston, Mass	4	287.68	14,600	1,256,000	16,874
Dennis, Mass	1	99.99	7,000	400,000	6,000
Provincetown, Mass	3	281.87	11,500	760,000	11,400
Total for Massachusetts ports	53	4,528.29	263,559	17,615,000	245,520
Grand total	72	5,408.68	298,959	22,524,000	279,297

* The names given are those of the hailing ports from which the vessels sail. The products are chiefly marketed at Gloucester, Boston, and New York.

† Including one vessel belonging at Philadelphia, Pa., which landed one fare at Boston.

18.—Table showing the quantity and value of frozen herring landed in the New England States by Canadian vessels in 1889.

Where from.	Boston.		Gloucester.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Newfoundland	1,425,000	$21,375	530,000	$7,950	1,955,000	$29,325
Nova Scotia	180,000	1,134	350,000	2,800	530,000	3,934
New Brunswick	108,000	680	.....	.....	108,000	680
Total	1,713,000	23,189	880,000	10,750	2,593,000	33,939

I. THE FISHERIES OF MAINE.

GENERAL SUMMARY AND STATISTICS.

Some of the industries and interests of Maine are of more importance than those of any other New England State and many developments are unique. In point of value of product of all the other New England States combined. In certain branches [illegible] the shore fisheries for cod, herring, mackerel and alewives and in the shore industries related to or dependent on the fisheries, such as sardine and lobster canning and ice manufacturing.

The figures presented are the census and other returns of Maine of commercial importance. Some of these statements were compiled in their entirety; the St. Croix was [illegible] the Penobscot, the Kennebec, the Androscoggin, and the Kennebunk by Mr. [illegible]

In the tables presented below, the condensed statistics for this State are given.

IV. Table of persons employed.

Men employed	No.
[illegible]	2,515
[illegible]	185
[illegible]	6,265
[illegible]	5,244
Total	14,129

III. Table of apparatus and capital.

Designation	No.	Value.
Vessels fishing (tonnage 11,470.44)	349	$623,000
[illegible]	....	201,487
Vessels transporting (tonnage 1,000.20)	50	75,475
[illegible]	..	13,100
[illegible]	5,000	215,534
Boats transporting only	82	21,935
Apparatus of capture: vessel fisheries:		
[illegible]	90	27,600
[illegible]	1,540	15,400
[illegible]		95,261
[illegible]	6,715	6,905
[illegible]	90	722
[illegible]	..	50
Apparatus of capture: shore fisheries:		
[illegible]	270	52,022
[illegible]	841	111,000
[illegible]	111	14,805
[illegible]	8,661	82,973
[illegible]	980	11,570
[illegible]	134	450
[illegible]	.	14,700
[illegible]	111	144
[illegible]	121,140	108,068
[illegible]	75	5,325
[illegible]	158	165
[illegible]	123	1,000
[illegible]	107	337
[illegible]		1,344
Shore property		743,000
Cash capital		671,000
Total		2,000,000

21.—Table of products.

Species.	Vessel fisheries.		Shore fisheries.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives, fresh	28,000	$195	2,360,225	$12,958	2,388,225	$13,153
Alewives, salted	14,000	161	598,180	8,498	612,180	8,659
Alewives, smoked	.....	.....	357,714	8,596	357,714	8,596
Bream, fresh	.....	.....	26,000	270	26,000	270
Butter-fish, fresh	.....	.....	27,000	445	27,000	445
Catfish, fresh	.....	.....	6,000	120	6,000	120
Cod, fresh	3,690,570	72,300	2,361,902	50,505	6,052,472	122,805
Cod, salted	9,961,556	275,538	1,520,682	38,853	11,482,238	314,391
Cunners, fresh	60,000	1,200	44,100	1,423	104,100	2,623
Cusk, fresh	86,500	760	281,100	3,881	367,600	4,641
Cusk, salted	129,970	1,315	23,559	240	153,529	1,555
Eels, fresh	7,250	610	95,895	8,125	103,145	8,735
Flounders, fresh	.....	.....	829,475	15,815	829,475	15,815
Frostfish or tomcod, fresh	.....	.....	348,550	3,236	348,550	3,236
Haddock, fresh	2,381,950	41,782	2,386,759	40,589	4,768,709	82,371
Haddock, salted	737,534	8,531	782,592	11,738	1,520,126	20,269
Hake, fresh	699,752	6,023	2,216,386	21,232	2,916,138	27,255
Hake, salted	3,791,924	40,668	1,416,547	21,248	5,208,471	61,916
Halibut, fresh	339,453	24,891	159,910	11,064	499,363	35,955
Halibut, salted	600	36	.....	.....	600	36
Herring, fresh	618,900	4,680	17,350,331	71,579	17,969,231	76,259
Herring, salted	2,497,200	34,827	2,712,725	28,846	5,209,925	63,673
Herring, smoked	.....	.....	3,185,925	99,639	3,185,925	99,639
Mackerel, fresh	181,251	14,472	236,190	21,602	417,441	36,074
Mackerel, salted	562,100	51,904	.....	.....	562,100	51,904
Menhaden, fresh	8,498,860	18,805	1,685,900	9,479	10,184,760	28,284
Pollock, fresh	1,380,513	12,906	958,003	9,669	2,338,516	22,575
Pollock, salted	575,176	5,804	383,546	4,000	958,722	9,804
Red snapper, fresh	285,000	7,100	.....	.....	285,000	7,100
Salmon, fresh	.....	.....	152,740	34,118	152,740	34,118
Shad, fresh	18,000	675	†69,800	18,012	887,800	18,687
Smelt, fresh	10,000	900	1,045,385	74,077	1,055,385	74,977
Swordfish, fresh	634,435	26,817	.....	.....	634,435	26,817
Waste fish, fresh	.....	.....	448,400	1,755	448,400	1,755
Lobsters	549,240	17,432	24,452,111	556,733	25,001,351	574,165
Scallops	32,614	1,950	262,685	16,697	*295,299	18,647
Clams (soft), fresh	35,020	1,582	2,207,072	72,359	‡2,242,092	73,941
Clams (soft), salted	.....	.....	6,181,600	126,820	‡6,181,600	126,820
Quahogs	.....	.....	800	100	§800	100
Algæ	.....	.....	12,900,000	6,315	12,900,000	6,315
Cod tongues	151,426	3,028	10,138	203	161,564	3,231
Cod and hake sounds	60,198	1,505	42,925	1,074	103,123	2,579
Oil	339,838	12,570	272,182	8,326	‖612,020	20,896
Total	38,358,830	690,967	91,201,034	1,420,239	129,559,864	2,111,206

*45,368 bushels. †224,209 bushels. ‡30,908 barrels. §100 bushels. ‖81,603 gallons.

THE VESSEL FISHERIES.

The vessel fisheries of Maine, while of considerable importance, are much less extensive than the shore fisheries, so far as the results of the industry are concerned. Their specially prominent feature is the large number of vessels of small size fishing on shore grounds. The herring and lobster fisheries are more important than in any other State. The mackerel fleet is relatively large. The vessels fishing for cod on the great offshore banks are comparatively few in number, but include some of the finest schooners in the New England fleet.

In the following tables the vessel fisheries are exhibited from four points of view, viz, by counties, by customs districts, by apparatus, and by fisheries.

Three tables give the details by counties. Vessels are employed in all the coast counties, eight in number.

The first table shows that of 2,680 persons in this branch, 2,515 were on fishing vessels and 165 on fishery transports. Cumberland County leads all others in the number of vessel fishermen, 857 persons, or 32 per cent, being credited to it. This is

followed by Hancock, Lincoln, and Knox counties, with from about 400 to 700 men each; Washington, with over 200; and York, Sagadahoc, and Waldo, with less than 100 each, the last-named county having only 4 vessel fishermen.

It is interesting to observe that 267 aliens are found among the Maine vessel fishermen. This is equivalent to 10 per cent of the whole number. The British provincial element greatly predominates, numbering 246, or 92 per cent of all aliens. Lincoln has more foreign vessel fishermen than any other county, after which are Cumberland and Hancock counties. The other counties have only a very small proportion of unnaturalized fishermen.

Table 23 shows that 349 fishing vessels and 59 transporters were employed in the waters of Maine in 1889, worth, with their outfits and apparatus, $959,090. Hancock County has the greatest number of vessels, although Cumberland County leads in tonnage and value. Of the vessels used in transporting fishery products, nearly half were owned in Washington County.

Purse seines to the number of 56 are used in five counties, Cumberland being credited with 31. Gill nets are found in every county, the total number fished being 1,540, of which Knox and Lincoln counties each have 360. Lines are the most valuable form of apparatus in the vessel fisheries, and are used in all the counties except Waldo. Lobster pots are naturally the most numerous apparatus and are employed to the number of 6,715 in all the counties but Waldo and Sagadahoc, the greatest number being in Washington County. Harpoons, dredges, and rakes complete the list; these are only sparingly used.

The products of the vessel fisheries, as shown in the third table of the series, amounted to 38,358,830 pounds, for which the fishermen received $690,967. Cumberland County leads all others in the quantity and value of products, being credited with nearly one-third the yield and more than one-third of the value of the catch in the entire State. Lincoln County ranks second in quantity of products, but is surpassed by Hancock in the value of output. Each of five counties shows products amounting to from over 1,000,000 pounds to upwards of 12,000,000. Cod, the most important species, is taken in largest quantity in Cumberland County, but the value of the cod caught by Hancock County vessels is greater than in Cumberland County, owing to the condition in which the product is sold.

22.—Table showing by counties the number and nationality of men employed in the vessel fisheries of Maine in 1889.

Counties.	Number and nationality of men on fishing vessels.				Number and nationality of men on transporting vessels.		
	Americans.	British provincials.	All others.	Total.	Americans.	British provincials.	Total.
Washington	130	5	.....	135	82	4	86
Hancock	631	55	13	699	31	.....	31
Waldo	2	.....	.....	2	2	.....	2
Knox	355	12	1	368	20	.....	20
Lincoln	298	101	2	401	3	.....	3
Sagadahoc	18	.....	.....	18	.....	.....	.....
Cumberland	760	69	5	834	23	.....	23
York	58	.....	.....	58	.....	.....	.....
Total	2,252	242	21	2,515	161	4	165

25.—Table showing by counties certain average figures for the vessels employed in the fisheries of Maine in 1889.

Counties.	Net tonnage.	Value per ton.	Value per vessel.	Value of apparatus and outfit.	No. of men to vessel.	Value of catch per man.	Value of catch per vessel.	Value of catch per each ton employed.	Value of catch per each $100 invested in fishing vessels.
Washington	16.05	$30	$479	$444	5	$161	$750	$47	$81
Hancock	37.06	39	1,430	1,175	7	271	1,997	54	76
Waldo	8.20	37	300	180	2	255	510	62	106
Knox	24.13	40	976	682	5	227	1,246	52	75
Lincoln	29.47	52	1,531	908	7	251	1,798	61	74
Sagadahoc	18.76	36	675	644	5	251	1,129	60	85
Cumberland	47.07	53	2,512	1,370	10	325	3,225	69	83
York	14.25	46	669	661	4	333	1,487	104	112

26.—Table showing by counties the percentage of value of each species or product taken in the vessel fisheries of Maine in 1889.

Species.	Washington.	Hancock.	Waldo.	Knox.	Lincoln.	Sagadahoc.	Cumberland.	York.
Alewives, fresh					.19			
Alewives, salted					.16			
Cod, fresh	2.18	.64		3.15	4.64	18.71	22.10	13.42
Cod, salted	29.63	75.27		21.24	37.97	18.82	24.26	19.18
Cunners, fresh							.44	
Cusk, fresh							.02	3.70
Cusk, salted		.08		.95	.29		.03	
Eels, fresh							.23	
Haddock, fresh	1.59	.32		4.95	6.82	7.86	9.59	18.10
Haddock, salted	1.20	.79		4.43	.53	2.99	.85	.57
Hake, fresh	.85	.07		3.53	1.06	1.77	.51	1.26
Hake, salted	9.67	8.36		14.92	4.03	7.19	1.88	3.88
Halibut, fresh	4.60	1.35		.03	1.11	5.53	7.33	.31
Halibut, salted		.02						
Herring, fresh		.99		.75	.54	5.09	.38	1.98
Herring, salted	17.97	3.73	100.00	15.33	7.38	18.26	.80	.59
Mackerel, fresh		.01		6.24	1.83	8.41	2.26	4.62
Mackerel, salted	6.62	2.77		8.34	12.74		9.29	1.24
Menhaden, fresh		.12		3.43	13.27		.86	.16
Pollock, fresh				.07	1.47		4.19	
Pollock, salted	3.05	.82		.70	1.17	2.66	.63	
Red snapper, fresh							2.62	
Shad, fresh							.25	
Smelt, fresh							.33	
Swordfish, fresh				3.11			8.49	6.31
Lobsters	20.20	.64		5.78	1.72		.35	22.29
Scallops		1.03						
Clams	.46				.77		.25	.16
Tongues	.36	.72		.27	.49	.27	.29	.27
Sounds	.28	.32		.57	.14	.27	.07	.12
Oil	1.34	1.95		2.21	1.68	2.17	1.70	1.84
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

In considering the vessel fisheries of Maine by customs districts, the most noticeable feature is the great preponderance of the Portland district in the matters of tonnage, value of vessels, number of crew, and stock of fishing vessels, although the number of fishing craft in the Waldoboro district is nearly as great as in Portland. The Passamaquoddy district leads all others in the extent and importance of its transporting fleet, the frozen-herring trade being a prominent feature of the fishing interests of the region.

Examination of the products table will show the districts in which the greatest quantities of each species are landed. The Portland district is conspicuous for the greatest catch of cod, haddock, mackerel, and swordfish, and Waldoboro leads in the yield of menhaden, hake, herring, pollock, and lobster.

27.—Summary by customs districts of the vessel fisheries of Maine in 1889.

Customs districts.	No. of vessels fishing.	Net tonnage.	Value of vessel.	Value of outfit, gear, provisions, fuel, etc.	Number and nationality of fishermen.				Value of catch.*
					Americans.	British provincials.	All others.	Total.	
Passamaquoddy	4	141.68	$3,980	$2,850	31	5	.....	36	$3,060
Machias	23	306.81	9,400	9,525	91	.....	.....	91	17,756
Frenchmans Bay	41	1,845.36	77,225	59,250	314	44	1	359	93,284
Castine	56	1,693.13	59,250	52,880	325	11	12	348	91,318
Belfast	14	515.37	21,225	21,555	118	3	.....	121	20,741
Waldoboro	80	1,511.08	58,735	37,280	361	9	1	371	92,559
Wiscasset	29	1,169.76	65,525	35,905	165	101	2	268	61,384
Bath	4	75.04	2,700	2,574	18	.....	.....	18	4,395
Portland	84	4,012.46	216,080	116,161	765	69	5	839	269,256
Saco	3	24.35	1,650	1,260	11	.....	.....	11	3,530
Kennebunk	9	165.58	7,500	7,610	48	.....	.....	48	15,849
York	2	15.82	500	575	5	.....	.....	5	732
Total	349	11,476.44	523,690	347,425	2,252	242	21	2,515	673,864

Customs districts.	No. of vessels transporting.	Net tonnage.	Value of vessel.	Value of provisions, fuel, etc.	Number and nationality of crew.				Value of products transported.
					Americans.	British provincials.	All others.	Total.	
Passamaquoddy	23	747.58	$36,150	$5,530	71	4	.....	75	$68,080
Machias	4	114.21	8,200	1,100	11	.....	.....	11	8,500
Frenchmans Bay	5	268.87	6,100	1,025	18	.....	.....	18	18,600
Castine	6	71.02	6,875	1,200	13	.....	.....	13	18,200
Belfast	3	88.87	2,450	400	8	.....	.....	8	5,350
Waldoboro	7	153.27	6,000	1,325	17	.....	.....	17	25,775
Wiscasset	.....	.....	.....	.....	.....	.....	.....	.....	.....
Bath	.....	.....	.....	.....	.....	.....	.....	.....	.....
Portland	11	216.41	9,700	2,520	23	.....	.....	23	56,939
Saco	.....	.....	.....	.....	.....	.....	.....	.....	.....
Kennebunk	.....	.....	.....	.....	.....	.....	.....	.....	.....
York	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total	59	1,660.23	75,475	13,100	161	4	.....	165	201,444

* In addition to the values given, $17,108 should be added for oil, cod tongues, and sounds.

28.—Table showing by species and customs districts the yield of the vessel fisheries of Maine in 1889.

Species.	Passamaquoddy.		Machias.		Frenchmans Bay.		Castine.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Cod, fresh	.....	.....	22,000	$475	38,840	$725	32,700	$495
Cod, salted	65,010	$1,515	185,640	4,770	2,461,622	75,112	2,043,764	67,879
Cusk, salted	.....	.....	.....	.....	12,140	135	2,000	15
Haddock, fresh	.....	.....	18,500	345	7,822	113	33,950	503
Haddock, salted	.....	.....	18,450	251	65,106	779	70,500	725
Hake, fresh	.....	.....	19,550	186	8,400	75	6,000	50
Hake, salted	.....	.....	133,240	1,821	871,481	9,487	643,746	6,661
Halibut, fresh	.....	.....	16,250	987	31,415	1,754	12,700	827
Halibut, salted	.....	.....	.....	.....	600	36	.....	.....
Herring, fresh	.....	.....	.....	.....	30,500	247	187,300	1,627
Herring, salted	.....	.....	250,000	3,911	175,000	2,475	316,600	4,611
Mackerel, fresh	.....	.....	.....	.....	.....	.....	350	28
Mackerel, salted	14,400	1,441	.....	.....	.....	.....	54,800	5,250
Menhaden, fresh	.....	.....	.....	.....	98,460	219	.....	.....
Pollock, salted	11,620	104	41,868	515	118,235	1,182	43,600	424
Lobsters	.....	.....	169,440	4,395	27,000	945	8,600	273
Scallops	.....	.....	.....	.....	.....	.....	32,614	1,950
Clams (soft)	.....	.....	2,500	100	.....	.....	.....	.....
Total	91,030	3,060	877,438	17,756	3,946,621	93,284	3,489,224	91,318

25.—Table showing by counties certain average figures for the vessels employed in the fisheries of Maine in 1889.

Counties.	Net tonnage.	Value per ton.	Value per vessel.	Value of apparatus and outfit.	No. of men to vessel.	Value of catch per man.	Value of catch per vessel.	Value of catch per each ton employed.	Value of catch per each $100 invested in fishing vessels.
Washington	16.05	$30	$479	$444	5	$161	$750	$47	$81
Hancock	37.06	39	1,430	1,175	7	271	1,907	54	76
Waldo	8.20	37	300	180	2	255	510	62	106
Knox	24.13	40	976	682	5	227	1,246	52	75
Lincoln	29.47	52	1,531	908	7	251	1,798	61	74
Sagadahoc	18.76	36	675	644	5	251	1,129	60	85
Cumberland	47.07	53	2,512	1,370	10	325	3,225	69	83
York	14.25	46	669	661	4	333	1,487	104	112

26.—Table showing by counties the percentage of value of each species or product taken in the vessel fisheries of Maine in 1889.

Species.	Washington.	Hancock.	Waldo.	Knox.	Lincoln.	Sagadahoc.	Cumberland.	York.
Alewives, fresh					.19			
Alewives, salted					.16			
Cod, fresh	2.18	.64		3.15	4.64	18.71	22.10	13.42
Cod, salted	29.63	75.27		21.24	37.97	18.82	24.26	19.18
Cunners, fresh							.44	
Cusk, fresh							.02	3.70
Cusk, salted		.08		.95	.29		.03	
Eels, fresh							.23	
Haddock, fresh	1.59	.32		4.95	6.82	7.86	9.59	18.10
Haddock, salted	1.20	.79		4.43	.53	2.99	.85	.57
Hake, fresh	.85	.07		3.53	1.06	1.77	.51	1.26
Hake, salted	9.67	8.38		14.92	4.03	7.19	1.88	3.88
Halibut, fresh	4.60	1.35		.03	1.11	5.53	7.33	.31
Halibut, salted		.02						
Herring, fresh		.99		.75	.54	5.09	.38	1.98
Herring, salted	17.97	3.73	100.00	15.33	7.38	18.26	.80	.59
Mackerel, fresh		.01		6.24	1.83	8.41	2.26	4.62
Mackerel, salted	6.62	2.77		8.34	12.74		9.29	1.24
Menhaden, fresh		.12		3.43	13.27		.86	.16
Pollock, fresh				.07	1.47		4.19	
Pollock, salted	3.05	.82		.70	1.17	2.66	.63	
Red snapper, fresh							2.62	
Shad, fresh							.25	
Smelt, fresh							.33	
Swordfish, fresh				3.11			8.49	6.31
Lobsters	20.20	.64		5.78	1.72		.35	22.29
Scallops		1.03						
Clams	.46				.77		.25	.16
Tongues	.36	.72		.27	.49	.27	.29	.27
Sounds	.28	.32		.57	.14	.27	.07	.12
Oil	1.34	1.95		2.21	1.68	2.17	1.70	1.84
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

In considering the vessel fisheries of Maine by customs districts, the most noticeable feature is the great preponderance of the Portland district in the matters of tonnage, value of vessels, number of crew, and stock of fishing vessels, although the number of fishing craft in the Waldoboro district is nearly as great as in Portland. The Passamaquoddy district leads all others in the extent and importance of its transporting fleet, the frozen-herring trade being a prominent feature of the fishing interests of the region.

Examination of the products table will show the districts in which the greatest quantities of each species are landed. The Portland district is conspicuous for the greatest catch of cod, haddock, mackerel, and swordfish, and Waldoboro leads in the yield of menhaden, hake, herring, pollock, and lobster.

27.—Summary by customs districts of the vessel fisheries of Maine in 1889.

Customs districts.	No. of vessels fishing.	Net tonnage.	Value of vessel.	Value of outfit, gear, provisions, fuel, etc.	Number and nationality of fishermen.				Value of catch.*
					Americans.	British provincials.	All others.	Total.	
Passamaquoddy	4	141.68	$3,900	$2,850	31	5	.....	36	$3,060
Machias	23	306.81	9,400	9,525	91	.....	.....	91	17,756
Frenchmans Bay	41	1,845.36	77,225	59,250	314	44	1	359	93,284
Castine	56	1,693.13	59,250	52,880	325	11	12	348	91,318
Belfast	14	515.37	21,225	21,555	118	3	.....	121	20,741
Waldoboro	80	1,511.08	58,735	37,280	361	9	1	371	92,559
Wiscasset	29	1,169.76	65,525	35,905	165	101	2	268	61,384
Bath	4	75.04	2,700	2,574	18	.....	.....	18	4,395
Portland	84	4,012.46	216,080	116,161	765	69	5	839	269,256
Saco	3	24.35	1,650	1,260	11	.....	.....	11	3,530
Kennebunk	9	165.58	7,500	7,610	48	.....	.....	48	15,849
York	2	15.82	500	575	5	.....	.....	5	732
Total	349	11,476.44	523,690	347,425	2,252	242	21	2,515	673,864

Customs districts.	No. of vessels transporting.	Net tonnage.	Value of vessel.	Value of provisions, fuel, etc.	Number and nationality of crew.				Value of products transported.
					Americans.	British provincials.	All others.	Total.	
Passamaquoddy	23	747.58	$36,150	$5,530	71	4	.....	75	$68,080
Machias	4	114.21	8,200	1,100	11	.....	.....	11	8,500
Frenchmans Bay	5	268.87	6,100	1,025	18	.....	.....	18	18,600
Castine	6	71.02	6,875	1,200	13	.....	.....	13	18,200
Belfast	3	88.87	2,450	400	8	.....	.....	8	5,350
Waldoboro	7	153.27	6,000	1,325	17	.....	.....	17	25,775
Wiscasset	.....	.....	.....	.....	.....	.....	.....	.....	.....
Bath	.....	.....	.....	.....	.....	.....	.....	.....	.....
Portland	11	216.41	9,700	2,520	23	.....	.....	23	56,939
Saco	.....	.....	.....	.....	.....	.....	.....	.....	.....
Kennebunk	.....	.....	.....	.....	.....	.....	.....	.....	.....
York	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total	59	1,660.23	75,475	13,100	161	4	.....	165	201,444

* In addition to the values given, $17,103 should be added for oil, cod tongues, and sounds.

28.—Table showing by species and customs districts the yield of the vessel fisheries of Maine in 1889.

Species.	Passamaquoddy.		Machias.		Frenchmans Bay.		Castine.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Cod, fresh	.....	.....	22,000	$475	38,840	$725	32,700	$495
Cod, salted	65,010	$1,515	185,640	4,770	2,461,622	75,112	2,043,764	67,879
Cusk, salted	.....	.....	.....	.....	12,140	135	2,000	15
Haddock, fresh	.....	.....	18,500	345	7,822	113	33,950	503
Haddock, salted	.....	.....	18,450	251	65,106	779	70,500	725
Hake, fresh	.....	.....	19,550	186	8,400	75	6,000	50
Hake, salted	.....	.....	133,240	1,821	871,481	9,487	643,746	6,661
Halibut, fresh	.....	.....	16,250	987	31,415	1,754	12,700	827
Halibut, salted	.....	.....	.....	.....	600	36	.....	.....
Herring, fresh	.....	.....	.....	.....	30,500	247	187,300	1,627
Herring, salted	.....	.....	250,000	3,911	175,000	2,475	316,600	4,611
Mackerel, fresh	.....	.....	.....	.....	.....	.....	350	28
Mackerel, salted	14,400	1,441	.....	.....	.....	.....	54,800	5,250
Menhaden, fresh	.....	.....	.....	.....	98,460	219	.....	.....
Pollock, salted	11,620	104	41,868	515	118,235	1,182	43,600	424
Lobsters	.....	.....	169,440	4,395	27,000	945	8,600	273
Scallops	.....	.....	.....	.....	.....	.....	32,614	1,950
Clams (soft)	.....	.....	2,500	100	.....	.....	.....	.....
Total	91,030	3,060	877,438	17,756	3,946,621	93,284	3,489,224	91,318

28.—Table showing by species and customs districts the yield of the vessel fisheries of Maine in 1889—Cont'd.

Species.	Belfast.		Waldoboro.		Wiscasset.		Bath.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives, fresh	.....	.....	20,000	$115	8,000	$80	.....	.....
Alewives, salted	.....	.....	14,000	161	.....	.....	.....	.....
Cod, fresh	29,000	$490	174,593	3,122	255,000	3,684	50,931	$845
Cod, salted	237,000	5,720	723,960	17,059	1,427,000	33,190	41,000	850
Cusk, salted	19,000	210	88,720	873	.....	.....	.....	.....
Haddock, fresh	227,850	3,067	92,954	1,171	400,500	6,760	23,673	355
Haddock, salted	95,000	1,040	268,820	3,146	3,000	45	13,830	135
Hake, fresh	1,550	15	484,665	3,974	2,000	25	8,587	80
Hake, salted	290,000	3,030	1,208,630	12,620	63,000	870	30,356	325
Halibut, fresh	500	25	.....	.....	15,700	1,118	4,198	250
Herring, fresh	.....	.....	199,600	1,174	.....	.....	28,000	230
Herring, salted	34,000	510	1,349,600	18,350	169,000	1,875	60,000	825
Mackerel, fresh	1,600	120	88,896	6,028	.....	.....	4,005	380
Mackerel, salted	59,800	5,625	19,800	1,706	86,300	8,500	.....	.....
Menhaden, fresh	18,000	75	6,721,200	13,886	720,000	2,000	.....	.....
Pollock, fresh	.....	.....	91,900	795	99,300	745	.....	.....
Pollock, salted	.....	.....	127,220	1,259	50,000	500	12,257	120
Swordfish, fresh	19,100	694	41,135	1,905	.....	.....	.....	.....
Lobsters	4,800	120	180,000	5,215	29,000	1,222	.....	.....
Clams (soft)	.....	.....	.....	.....	14,720	770	.....	.....
Total	1,037,200	20,741	11,895,693	92,559	3,342,520	61,384	276,837	4,395

Species.	Portland.		Saco.		Kennebunk.		York.		Total for State.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives, fresh	.....	.....	.....	.....	.....	.....	.....	.....	28,000	$195
Alewives, salted	.....	.....	.....	.....	.....	.....	.....	.....	14,000	161
Cod, fresh	2,912,706	$59,070	21,700	$433	141,600	$2,726	11,500	$235	3,690,570	72,300
Cod, salted	2,600,560	65,735	.....	.....	176,000	3,708	.....	.....	9,961,556	275,538
Cunners, fresh	60,000	1,200	.....	.....	.....	.....	.....	.....	60,000	1,200
Cusk, fresh	5,000	45	.....	.....	65,000	585	16,500	130	86,500	760
Cusk, salted	8,110	82	.....	.....	.....	.....	.....	.....	129,970	1,315
Eels, fresh	7,250	610	.....	.....	.....	.....	.....	.....	7,250	610
Haddock, fresh	1,377,201	25,769	15,500	310	180,500	3,329	3,500	60	2,381,950	41,782
Haddock, salted	192,828	2,300	.....	.....	10,000	110	.....	.....	737,534	8,531
Hake, fresh	141,250	1,375	.....	.....	21,750	188	6,000	55	699,752	6,023
Hake, salted	494,471	5,104	.....	.....	57,000	750	.....	.....	3,791,924	40,668
Halibut, fresh	254,790	19,660	.....	.....	3,900	270	.....	.....	339,453	24,891
Halibut, salted	.....	.....	.....	.....	.....	.....	.....	.....	600	36
Herring, fresh	124,000	1,020	2,300	22	27,200	190	20,000	170	618,900	4,680
Herring, salted	136,000	2,155	.....	.....	7,000	115	.....	.....	2,497,200	34,827
Mackerel, fresh	76,700	7,023	1,200	120	8,000	723	500	50	181,251	14,472
Mackerel, salted	323,800	29,142	200	15	3,000	225	.....	.....	562,100	51,904
Menhaden, fresh	932,200	2,595	.....	.....	9,000	30	.....	.....	8,498,860	18,805
Pollock, fresh	1,189,313	11,366	.....	.....	.....	.....	.....	.....	1,380,513	12,906
Pollock, salted	170,376	1,700	.....	.....	.....	.....	.....	.....	575,176	5,804
Red snapper, fresh	285,000	7,100	.....	.....	.....	.....	.....	.....	285,000	7,100
Shad, fresh	18,000	675	.....	.....	.....	.....	.....	.....	18,000	675
Smelt, fresh	10,000	900	.....	.....	.....	.....	.....	.....	10,000	900
Swordfish, fresh	543,600	22,998	800	30	29,800	1,190	.....	.....	634,435	26,817
Lobsters	20,400	952	60,000	2,600	50,000	1 710	.....	.....	549,240	17,432
Scallops	.....	.....	.....	.....	.....	.....	.....	.....	32,614	1,950
Clams (soft)	17,000	680	.....	.....	.....	.....	800	32	35,020	1,582
Total	11,900,555	269,256	101,700	3,530	789,750	15,849	58,800	732	37,807,368	673,864

Table 29, based on the preceding, gives certain average figures for the vessels in the various districts. The points shown are average tonnage, average value, average value of apparatus and outfit, average number of crew, and average gross stock.

29.—Table showing by customs districts the average tonnage, value, crew, and stock of vessels employed in the fisheries of Maine in 1889.

Customs districts.	Average tonnage.		Average value.		Average value of outfit and apparatus.		Average number of crew.		Average gross stock.	
	Fishing.	Transporting.	Fishing.	Transporting.	Fishing.	Transporting.	Fishing.	Transporting.	Fishing.	Transporting.
Passamaquoddy	35.42	32.50	$975	$1,572	$713	$240	9	3	$765	$2,960
Machias	13.34	28.55	409	2,050	414	275	4	3	772	2,125
Frenchmans Bay	45.01	53.77	1,884	1,220	1,443	205	9	4	2,275	3,720
Castine	30.23	11.84	1,058	1,146	944	200	6	2	1,631	3,033
Belfast	36.81	29.62	1,516	817	1,540	133	9	3	1,482	1,783
Waldoboro	18.89	21.90	734	857	466	189	5	2	1,157	3,682
Wiscasset	40.34	.....	2,259	.....	1,258	.....	9	.....	2,117	.....
Bath	18.76	.....	675	.....	644	.....	5	.....	1,086	.....
Portland	47.77	19.67	2,572	882	1,383	229	10	2	3,205	5,176
Saco	8.12	.....	550	.....	420	.....	4	.....	1,177	.....
Kennebunk	18.40	.....	833	.....	846	.....	5	.....	1,761	.....
York	7.91	.....	250	.....	288	.....	3	.....	366	.....

[1] The value of products transported.

The relative importance of the different kinds of apparatus employed in the vessel fisheries in the capture of fish is shown in Table 30. It appears that by means of hand lines and trawl lines 24,126,298 pounds of fish, valued at $503,267, were taken, these figures representing about 65 per cent of the total catch and 77 per cent of the aggregate value. Salt cod is by far the most important item in the line fishery, the value of this species in this condition being more than that of all the other line fish combined. Seines rank next to lines in both quantity and value of fish. Of the 9,030,960 pounds taken by this means, 8,498,860 pounds were menhaden; but of the total value of seine-caught fish, viz, $67,777, mackerel represented $48,297. After seines come gill nets with 3,391,551 pounds, worth $54,429, of which the herring amounted to 3,116,100 pounds, valued at $39,507. Harpoons and pots complete the list of apparatus in the vessel fisheries; the catch by these forms is restricted to swordfish and eels, and is necessarily insignificant in comparison with the other kinds of apparatus, although the 634,435 pounds of swordfish, valued at $26,817, represent an important fishery.

30.—Table showing by apparatus and species the yield of the vessel fisheries of Maine in 1889, exclusive of the molluscan and crustacean fisheries.

Apparatus and species.	Pounds.	Value.	Apparatus and species.	Pounds.	Value.
Seines:			Lines:		
Mackerel, fresh	33,500	$3,135	Cod, fresh	3,690,570	$72,300
Mackerel, salted	480,600	45,162	Cod, salted	9,961,556	275,538
Menhaden, fresh	8,498,860	18,805	Cusk, fresh	86,500	760
Shad, fresh	18,000	675	Cusk, salted	129,970	1,315
Total	9,030,960	67,777	Haddock, fresh	2,381,950	41,782
Gill nets:			Haddock, salted	737,534	8,531
Alewives, fresh	28,000	196	Hake, fresh	699,752	6,023
Alewives, salted	14,000	161	Hake, salted	3,791,924	40,668
Cunners or perch, fresh	60,000	1,200	Halibut, fresh	339,453	24,891
Herring, fresh	618,900	4,680	Halibut, salted	600	36
Herring, salted	2,497,200	34,827	Mackerel, fresh	15,300	1,373
Mackerel, fresh	132,451	9,964	Mackerel, salted	50,500	4,240
Mackerel, salted	31,000	2,502	Pollock, fresh	1,380,513	12,906
Smelt, fresh	10,000	900	Pollock, salted	575,176	5,804
Total	3,391,551	54,429	Red snapper, fresh	285,000	7,100
Pots:			Total	24,126,298	503,267
Eels, fresh	7,250	610	Grand total	37,190,494	652,900
Harpoons:					
Swordfish, fresh	634,435	26,817			

As already explained in discussing the general statistics which precede the chapter on the fisheries of Maine, in the presentation by fisheries each vessel is credited in the following table to all the fisheries in which it was engaged during any portion of the year, together with its tonnage, value, and crew, the object being to show the actual extent of each fishery. By far the greatest number of vessels were engaged in shore fishing, which is credited with 217 sail, after which come the herring fishery with 107 vessels, the mackerel fishery with 80 vessels, the bank cod fishery with 48 vessels, the lobster fishery with 29 vessels, and the swordfish fishery with 25 vessels.

31.—Table showing the number of vessels engaged in each fishery in Maine in 1889, together with their tonnage, value, and number of crew.

Fisheries.	No. of vessels engaged.	Net tonnage.	Value of vessels.	Number and nationality of fishermen.			
				Americans.	British provincials.	All others.	Total.
Cod, on banks east of 65° W. longitude	48	4,257.12	$214,900	581	191	1	773
Halibut	4	334.09	21,500	52	.....	.....	52
Mackerel, Gulf of St. Lawrence	4	327.90	20,500	67	.....	.....	67
Mackerel, New England and Cape shores	76	2,340.19	126,400	467	37	13	517
Shore	217	4,755.82	185,090	1,176	48	1	1,225
Market	18	1,210.62	64,900	212	25	7	244
Herring	107	1,908.01	69,000	454	.....	1	455
Swordfish	25	700.51	34,050	156	1	.....	157
Menhaden	20	641.52	23,110	163	.....	.....	163
Alewife	3	41.45	1,525	14	.....	.....	14
Clam	5	70.96	2,225	22	.....	.....	22
Scallop	2	26.12	650	8	.....	.....	8
Lobster	29	370.64	14,825	101	1	.....	102

In Table 32 the mackerel catch by fishing-grounds is given. It is interesting to observe that of the four vessels fishing for mackerel in the Gulf of St. Lawrence the average catch was only 1,250 pounds, while of the seventy-six on the New England and Nova Scotia shores the average yield was 9,715 pounds; the average stocks for the same vessels were $112 and $867, respectively.

32.—Table showing by fishing-grounds and apparatus the catch of the mackerel fleet of Maine in 1889.

Species.	New England shore.		Gulf of St. Lawrence.		Nova Scotia shore.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Mackerel caught with seines, fresh	33,500	$3,135	.....	.....	.....	.....	33,500	$3,135
Mackerel caught with seines, salted	471,400	44,271	5,000	$450	4,200	$441	480,600	45,162
Mackerel caught with nets, fresh	132,451	9,964	.....	.....	.....	.....	132,451	9,964
Mackerel caught with nets, salted	31,000	2,502	.....	.....	.....	.....	31,000	2,502
Mackerel caught with lines, fresh	15,300	1,373	.....	.....	.....	.....	15,300	1,373
Mackerel caught with lines, salted	50,500	4,240	.....	.....	.....	.....	50,500	4,240
Total	734,151	65,485	5,000	450	4,200	441	743,351	66,376

The shore fishery, as shown in Table 33, yields the largest quantities of fish and the greatest money returns. Of the 37,807,368 pounds, valued at $673,864, taken in the vessel fisheries of the State, 14,318,899 pounds, valued at $228,386, were obtained in the shore fishery, cod, hake, pollock, and haddock being the principal species. The cod vessels frequenting banks east of 65° west longitude brought in 6,275,907 pounds, valued at $190,423. After these, in the order of their importance, are the market, mackerel, herring, swordfish, menhaden, halibut, lobster, and molluscan fisheries.

33.—Table showing by fisheries and species the yield of the vessel fisheries of Maine in 1889.

Fisheries and species.	Pounds.	Value.
Banks east of 65° W. longitude:		
Cod, salted	6,275,907	$190,423
Halibut:		
Halibut, fresh	202,338	15,992
Shore:		
Alewives, fresh	28,000	195
Alewives, salted	14,000	161
Cod, fresh	1,979,954	38,761
Cod, salted	3,593,361	83,120
Cunners, fresh	60,000	1,200
Cusk, fresh	86,500	760
Cusk, salted	129,970	1,315
Eels, fresh	7,250	610
Haddock, fresh	1,092,950	19,500
Haddock, salted	737,534	8,531
Hake, fresh	699,752	6,023
Hake, salted	3,791,924	40,668
Halibut, fresh	113,415	7,221
Halibut, salted	600	36
Pollock, fresh	1,380,513	12,906
Pollock, salted	575,176	5,804
Shad, fresh	18,000	675
Smelt, fresh	10,000	900
Total	14,318,899	228,386
Mackerel:		
Mackerel, fresh	181,251	14,472
Mackerel, salted	562,100	51,904
Total	743,351	66,376
Market:		
Cod, fresh	1,710,616	$33,539
Cod, salted	92,288	1,995
Haddock, fresh	1,289,000	22,282
Halibut, fresh	23,700	1,678
Red snapper, fresh	285,000	7,100
Total	3,400,604	66,594
Menhaden:		
Menhaden, fresh	8,498,860	18,805
Herring:		
Herring, fresh	618,900	4,680
Herring, salted	2,497,200	34,827
Total	3,116,100	39,507
Swordfish:		
Swordfish, fresh	634,435	26,817
Molluscan:		
Scallops, fresh	32,614	1,950
Clams, fresh	35,020	1,582
Total	67,634	3,532
Crustacean:		
Lobsters, fresh	549,240	17,432
Grand total	37,807,368	673,864

THE SHORE FISHERIES.

Under this head are included all those fisheries prosecuted from boats or from the shore without the aid or use of vessels, although, as in the case of the lobster fishery, vessels may be employed to take the catch of the shore fishermen to market, in which case they are recorded as transporters.

The shore fisheries of Maine are of much greater consequence than those of any other New England State, and are more than double the importance of the vessel fisheries of the State, so far as the value of the products is concerned.

In the tables the extent of the industry is shown by counties and by apparatus, and some of the more important fisheries are discussed at length. In the first three tables the condensed figures for the shore fisheries are given for each county. The first tabular statement shows that of the total number of fishermen, viz, 6,205, Hancock County had 1,730, the greatest number, followed by Cumberland County with 1,105 and Washington County with 1,076. The other counties ranged from 744 in Lincoln to 43 in Penobscot.

Of the total sum invested in the shore fisheries, viz, $515,095, $237,469, or nearly half, represents boats, which are employed to the number of 5,990. In the number of boats Hancock County is first with 1,371, valued at $62,962, closely followed by Cumberland County with 1,232, worth $40,348, although in the item of value of boats Washington County ranks second, the 930 boats there used being worth $59,106. Penobscot County has only 24 boats, valued at $248.

Lobster pots are the most numerous form of apparatus of capture in the shore fisheries, and their aggregate value is far in excess of that of any other device. In 1889 they were used to the number of 121,250, the value of which was $108,812. Washington and Hancock counties had 65,861 pots, or considerably more than half. Knox, Lincoln, and Cumberland counties each had between 10,000 and 20,000 pots.

The next most valuable forms of apparatus are the weirs, of which 273, valued at $52,022, were operated in 1889. They are chiefly used in the capture of herring for smoking and canning, and are most numerous in the region east of the Penobscot River, especially in Washington County, which has more than half of the total number set in the State.

Trap nets rank next to weirs in value. They are chiefly used in the region west of and including the Penobscot River, in the counties of Hancock, Waldo and Sagadahoc. Salmon is the species for which they are principally set. The value of the trap nets operated in 1889 was $33,000.

Gill nets are important means of capture in all counties but Penobscot and Waldo. Over 3,500 were fished in 1889, the value of which was $32,973.

Pound nets are sparingly used in five counties, the greatest number being in Cumberland County. The total number set was 33, valued at $14,895, pound nets thus being relatively the most expensive form of apparatus in the shore fisheries of Maine.

Nearly equal in point of value to pound nets are the hand lines and trawl lines, worth $14,790. These are extensively used in all counties but Penobscot and Waldo, which have no ocean frontage and are therefore not interested in the line fisheries for ground fish which the position of the other counties makes important.

The only other forms of apparatus deserving special mention are bag nets and seines. The former are used to the number of 280, chiefly in the eastern counties; their total value is $11,570. Seines are most extensively employed in Hancock and Cumberland counties, which have 70 of the 75 seines fished in the State, Lincoln County having only 5 and none of the other counties having any.

Considering the aggregate investment by counties, it is seen that Hancock County takes the first position with $141,031, after which come Washington County with $113,987, Cumberland County with $69,626, and Knox County with $50,113. Sagadahoc, York, and Lincoln counties have from $34,000 to $45,000 each; Waldo County has only $16,382 and Penobscot County only $1,658.

The table of products shows 91,201,034 pounds of fish, mollusks, crustaceans, etc., taken in the shore fisheries of Maine in 1889; these were worth, at first hands, $1,420,239. Hancock County is considerably in advance of any other county in both the quantity and value of products, the figures being 27,017,744 pounds, valued at $428,711, of which 8,374,771 pounds, with a value of $197,089, represent lobsters. Second in rank is Washington County, with 21,148,162 pounds, worth $275,981; here the most important species is herring, of which 9,118,550 pounds, valued at $116,159, were taken, followed by lobsters, the catch of which was 7,251,790 pounds, for which the

fishermen received $109,084. Cumberland County comes after Washington County, showing a catch of 12,996,601 pounds, worth $230,770; in this county clams take precedence in quantity and value, 3,518,069 pounds being the output in 1889, worth to the fishermen $84,296. In Knox County, with its quota of 10,411,260 pounds, valued at $154,429, lobsters are by far the most important product, the yield of that species being 3,779,800 pounds, with a value of $105,108. The only remaining county with an output worth over $100,000 is Lincoln, in which 8,875,934 pounds of fishery products were secured, which yielded $132,286; in this county the lobster is also the most important single product, 1,693,250 pounds, valued at $52,138, being taken. The other counties, in the order of their rank, are York with products worth $84,161; Sagadahoc with $69,393; Waldo with $41,800 and Penobscot with the small sum of $2,708.

34.—Table showing by counties the number of persons engaged in the shore fisheries of Maine in 1889.

Counties.	No.
Washington	1,076
Hancock	1,730
Penobscot	43
Waldo	207
Knox	491
Lincoln	744
Sagadahoc	536
Cumberland	1,105
York	273
Total	6,205

35.—Table showing by counties the apparatus employed in the shore fisheries of Maine in 1889.

Designation.	Washington.		Hancock.		Penobscot.		Waldo.		Knox.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Boats	930	$59,106	1,371	$62,962	24	$248	236	$4,053	616	$20,782
Weirs	173	29,947	43	11,130	.....	.....	3	120	28	8,767
Pound nets	.....	.....	3	1,000	.....	.....	.....	.....	.....	.....
Trap nets	4	375	126	10,505	2	115	114	8,135	6	220
Bag nets	98	2,570	67	3,630	25	1,125	53	2,550	3	125
Gill nets	172	1,684	318	3,235	19	152	.....	.....	210	1,890
Fyke nets	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Seines	.....	.....	48	3,025	.....	.....	.....	.....	.....	.....
Lines	.....	731	.....	2,070	.....	.....	.....	11	.....	1,623
Pots	21,714	19,288	44,147	41,753	15	11	1,856	1,484	19,215	16,566
Spears	6	6	122	127	5	7	.....	.....	.....	.....
Scallop dredges	.....	.....	82	1,070	.....	.....	.....	.....	.....	.....
Clamming apparatus	.....	103	.....	494	.....	.....	.....	29	.....	90
Miscellaneous nets	64	177	22	30	.....	.....	.....	.....	8	50
Total	.....	113,987	.....	141,031	.....	1,658	.....	16,382	.....	50,113

Designation.	Lincoln.		Sagadahoc.		Cumberland.		York.		Total.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Boats	464	$22,382	361	$9,048	1,232	$40,348	756	$18,540	5,990	$237,469
Weirs	13	238	.....	.....	13	1,820	.....	.....	273	52,022
Pound nets	1	300	4	4,200	20	6,495	5	2,900	33	14,895
Trap nets	.....	.....	89	13,650	.....	.....	.....	.....	341	33,000
Bag nets	.....	.....	34	1,570	.....	.....	.....	.....	280	11,570
Gill nets	708	5,351	234	2,895	711	6,071	1,189	11,695	3,561	32,973
Fyke nets	31	75	2	50	101	425	.....	.....	134	550
Seines	5	150	.....	.....	22	2,150	.....	.....	75	5,325
Lines	.....	3,523	.....	459	.....	3,720	.....	2,653	.....	14,790
Pots	12,875	11,937	2,565	2,051	10,394	8,099	8,470	7,623	121,250	108,812
Spears	25	25	.....	.....	.....	.....	.....	.....	158	155
Scallop dredges	36	468	5	65	.....	.....	.....	.....	123	1,603
Clamming apparatus	.....	63	.....	142	.....	498	.....	165	.....	1,584
Miscellaneous nets	13	80	.....	.....	.....	.....	.....	.....	107	337
Total	.....	44,592	.....	34,130	.....	69,626	.....	43,576	.....	515,095

36.—Table showing by counties and species the yield of the shore fisheries of Maine in 1889.

Species.	Washington.		Hancock.		Penobscot.		Waldo.		Knox.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives, fresh	29,500	$185	36,290	$532			92,865	$480	384,250	$1,537
Alewives, salted	248,600	4,326	29,240	485			340	7		
Alewives, smoked	17,800	550	226,324	5,432			18,465	564	77,500	1,550
Cod, fresh	48,770	1,033	256,882	5,445					185,750	3,937
Cod, salted	303,210	7,741	913,921	23,334			2,000	51	124,771	3,211
Cusk, fresh			1,600	22						
Cusk, salted			17,959	182						
Eels, fresh	1,000	95	70,325	6,296	3,500	$250				
Flounders, fresh			666,275	14,009			1,200	36		
Frostfish, fresh	52,750	1,951	150,550	207	50,000	450	75,250	548		
Haddock, fresh	95,948	1,630	138,511	2,354			2,000	33	296,000	5,049
Haddock, salted	162,905	2,443	427,898	6,417					104,669	1,569
Hake, fresh	35,420	206	237,466	2,255			4,000	60	258,000	2,551
Hake, salted	307,650	4,614	726,738	10,900					80,239	1,206
Halibut, fresh	59,480	4,114	66,080	4,569						
Herring, fresh	6,106,625	19,333	6,451,556	24,234					3,026,250	11,662
Herring, salted	35,000	3,900	306,325	4,307					246,000	3,300
Herring, smoked	2,976,925	92,926	196,500	6,338					12,500	375
Menhaden, fresh			4,800	13						
Pollock, fresh	95,003	372	23,600	246					30,400	314
Pollock, salted	119,991	1,250	206,755	2,160			800	8		
Salmon, fresh	2,195	295	65,590	15,554	2,183	990	70,849	14,659	3,700	840
Shad, fresh	20,000	741	2,000	107			80	3		
Smelt, fresh	97,650	6,071	291,269	24,445	12,730	1,018	84,136	6,753	5,000	500
Waste fish, fresh	29,400	38					140,000	262		
Lobsters, fresh	7,251,790	109,084	8,374,771	197,089			317,000	11,552	3,779,800	105,108
Clams (soft), fresh	66,965	2,609	332,078	13,770			147,700	6,751	100,000	3,000
Clams (soft), salted	437,000	7,358	2,214,040	41,191			1,600	30	220,000	7,280
Scallops, fresh			177,660	11,972						
Algæ	2,500,000	1,250	4,300,000	2,015					1,450,000	725
Sounds	9,323	233	22,022	551			121	3	2,431	61
Tongues	2,030	41	6,092	122					832	17
Oil	35,232	1,592	76,627	2,158					23,168	637
Total	21,148,162	275,981	27,017,744	428,711	68,413	2,708	958,406	41,800	10,411,260	154,429

Species.	Lincoln.		Sagadahoc.		Cumberland.		York.		Total for the State.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives, fresh	766,675	$6,592	274,100	$1,902	776,545	$1,730			2,360,225	$12,958
Alewives, salted	320,000	3,680							598,180	8,498
Alewives, smoked	17,625	500							357,714	8,596
Bream, fresh			26,000	270					26,000	270
Butter-fish, fresh					18,000	300	9,000	$145	27,000	445
Catfish, fresh			6,000	120					6,000	120
Cod, fresh	576,000	12,211	65,000	1,378	565,000	11,988	664,500	14,513	2,361,902	50,505
Cod, salted	176,780	4,516							1,520,682	38,853
Cunners, fresh			16,000	585	25,300	785	2,800	53	44,100	1,423
Cusk, fresh	73,500	1,015	25,000	344	165,000	2,280	16,000	220	281,100	3,881
Cusk, salted	5,600	58							23,559	240
Eels, fresh	9,570	764	2,000	140	8,000	480	1,500	100	95,895	8,125
Flounders, fresh	25,000	230			92,000	1,210	45,000	330	829,475	15,815
Frostfish, fresh			20,000	80					348,550	3,236
Haddock, fresh	53,800	914	36,000	612	1,007,500	17,127	759,000	12,903	2,386,759	40,589
Haddock, salted	85,120	1,276							782,592	11,738
Hake, fresh	542,500	5,253			968,000	9,299	175,000	1,668	2,216,386	21,232
Hake, salted	297,920	4,468							1,416,547	21,248
Halibut, fresh	7,550	520			19,000	1,311	7,800	550	159,910	11,064
Herring, fresh	326,000	2,045	200,000	1,600	1,011,500	10,920	228,400	1,785	17,350,331	71,579
Herring, salted	1,667,000	12,715					458,400	4,624	2,712,725	28,846
Herring, smoked									3,185,925	99,639
Mackerel, fresh			100,000	9,880	74,160	5,228	62,030	6,494	236,190	21,602
Menhaden, fresh			50,000	150	1,372,500	7,230	258,600	2,066	1,685,900	9,479
Pollock, fresh	49,700	497	160,000	1,820	592,300	6,340	7,000	80	958,003	9,669
Pollock, salted	56,000	582							383,546	4,000
Salmon, fresh			5,683	1,225	2,240	500	300	55	152,740	34,118
Shad, fresh			738,583	14,451	108,137	2,660	1,000	50	869,800	18,012
Smelt, fresh	77,600	7,170	248,500	14,590	196,500	10,630	32,000	2,900	1,045,385	74,077
Waste fish, fresh					279,000	1,455			448,400	1,755
Lobsters, fresh	1,693,250	52,138	270,500	8,410	2,143,600	53,507	621,400	19,845	24,452,111	556,733
Clams (soft), fresh	92,580	3,388	59,460	1,846	1,040,009	29,869	368,280	11,126	2,207,072	72,359
Clams (soft), salted	217,400	4,725	509,000	9,620	2,478,060	54,427	104,500	2,189	6,181,600	126,820
Scallops, fresh	78,650	4,420	6,375	305					262,685	16,697
Quahogs, fresh							800	100	800	100
Algæ	1,600,000	800					3,050,000	1,525	12,900,000	6,315
Sounds	9,028	226							42,925	1,074
Tongues	1,184	23							10,138	203
Oil	49,902	1,560	2,325	65	54,250	1,494	29,678	820	272,182	8,326
Total	8,875,934	132,286	2,820,526	69,393	12,996,601	230,770	6,902,988	84,161	91,201,034	1,420,239

The most important shore fisheries in Maine are those for lobsters, herring, clams, ground fish, smelt, salmon, and shad. Each of these requires a short notice.

The lobster.—In considering the quantities of the different species making up the aggregate catch in the shore fisheries of Maine, the prominent place occupied by the lobster is clearly shown. The lobster fishery is the most important one in which the citizens of Maine are employed. More people are engaged in the capture of lobsters than of any other single product, and the value of the output in 1889 was more than one-fourth that of the entire yield of the fisheries of the State, being $574,165. As compared with 1880, the lobster catch has greatly increased, and the fishery is becoming more important each year, this being evidenced as much by the increasing attention bestowed on the subject of lobster protection and preservation by the State authorities as by the larger output. Statistics of the fishery for the four years, 1880, 1887, 1888, and 1889, are here presented side by side for comparison. It is thought that the catch in the last-named year was the largest in the history of the State.

Years.	Pounds.	Value.
1880	14,234,182	$344,693
1887	22,916,642	512,044
1888	21,694,731	515,880
1889	25,001,351	574,165

The comparatively small quantities of lobsters taken in the vessel fishery are included in the table in order to make the comparison more complete, there being no separate figures for the shore catch in 1880.

The herring.—The herring is the most important species in the shore fisheries of the State, with the exception of the lobster; in the vessel fisheries the cod has greater value; but if the canning industry and trade in smoked fish are taken into consideration the herring easily assumes the first place among the products of the Maine fisheries, and the species is by far the most abundant commercial fish in the waters of the State. In 1889, 23,248,981 pounds were sold fresh, salted, and smoked, for which the fishermen received $200,064, these figures being in addition to the vessel catch already referred to.

Since 1885 the herring fishery of Maine has undergone a noticeable increase, which has been chiefly due to the abrogation of the Washington treaty. The manufacturing enterprises connected with the canning of lobsters, the canning and smoking of herring, etc., have steadily increased, and new life and new capital have been put into the industry to meet the demand for larger supplies of raw materials, among which herring rank first in quantity and importance. The increase in the number of weirs and other appliances of capture has been more marked each year, and the growth and extension westward of the fishery and the dependent shore industries has been one of the most noteworthy features of the fisheries of this State during the past decade.

An increase in the herring weir fisheries has in most localities been attended with a corresponding increase in the smoked-herring business, but in the region of Mount Desert Island a most interesting and important exception to this rule is to be observed, due to its favorable location as a baiting rendezvous for the bank cod fishermen of both Maine and Massachusetts. In this vicinity the increase in the number of herring

weirs has had no appreciable effect on the smoking of herring, the smokehouses being more neglected than ever before. This condition is due to the circumstance that herring can be sold fresh for bait at better prices than would result from smoking them. The demand for bait in this section is now so constant and so great that the weir fishermen have not been able to meet it, and an extensive herring fishery with gill nets has been inaugurated within the past three years to supplement the weir fishery. At the Cranberry Isles and also in the vicinity of Southwest Harbor and Bar Harbor large numbers of bank and shore vessels are baited each year, and the practice of taking bait in this vicinity is annually becoming more popular and of increasing importance to the deep-sea fisheries. Prior to the building of weirs there was little or no baiting done here, and vessels were obliged to resort to more distant places and often had to go to the provinces at great loss of time.

The marked effect which the expiration of the reciprocity treaty with Canada has had on the development of the fisheries and fishery industries of the entire eastern coast of Maine has been nowhere more noticeable than in the increased facilities afforded American vessels to procure an abundant supply of bait in home ports through the building of brush weirs.

The soft clam.—This important species ranks third in value in the shore fisheries of Maine, being surpassed by the herring by only a few hundred dollars. In the table the yield of fresh clams is given at 2,207,072 pounds, valued at $72,359; these figures include the clams sold fresh for food, and also those which are subsequently canned. Much the larger part of the clam product is salted by the fishermen to be used as bait in the line fisheries. As shown by the table, 6,181,600 pounds of clam meats were thus prepared, for which the fishermen obtained $126,820. The value of salt clams as bait makes this fishery one of the most important in the State. The output in 1889 represented 30,908 barrels of salt bait, with an average value of $4.10 per barrel.

The cod, haddock, hake, and other ground fish.—The catch of the species commonly designated "ground fish," including cod, cusk, haddock, hake, halibut, and pollock, will, if taken in the aggregate, have a value somewhat greater than the herring, although no three of these species together yield the fishermen so much as the last-named fish. Among the ground fish taken in the shore fisheries the cod ranks first, with 3,882,584 pounds of fresh and salted fish, worth, at first hands, $89,358. Haddock come next in value, with $52,327, though the quantity of fresh and salted haddock sold, viz, 3,169,351 pounds, is less than the catch of hake, which amounted to 3,632,933 pounds, but sold for only $42,480. The yield of pollock was 1,341,549 pounds, with a value of $13,669, followed by the halibut with 159,910 pounds, all of which was sold fresh for $11,064, and the cusk with 304,659 pounds, valued at $4,121.

The smelt.—One of the most important food species occurring in the coast rivers of Maine is the smelt, a fish whose value to the State is second only to that of the lobster, herring, clam, and cod. It is by far the most important river fish in Maine, easily surpassing in economic value the salmon, shad, alewife, and other species that enter fresh water. The quantity taken in 1889 was 1,045,385 pounds, worth $74,077, or an average of over 7 cents per pound. The specially important rivers in which smelt are taken are the Bagaduce, Penobscot, and Kennebec.

The salmon.—This, the most highly esteemed of the food-fishes of Maine, is chiefly abundant in the Penobscot River, in which more than seven-eighths of the yield is taken. Practically, the entire catch is obtained in weirs and trap nets. The preservation of the salmon in the State is largely dependent on the artificial stocking of the streams by the introduction of fry hatched at the Government stations on the Penobscot. The catch varies considerably from year to year, and in 1889 was less than in the two preceding years, being 152,740 pounds, against 185,637 pounds in 1887 and 205,149 pounds in 1888. The yield in 1889 was worth $34,118, giving the fish an average value of 29 cents a pound.

The shad.—The catch of shad in Maine waters is now greater than in any other New England State, although in 1880 the output of the Connecticut fishery was more than double that of Maine. The fishery has undergone a considerable advance since 1880 and is no doubt still capable of great development. Almost the entire yield is taken west of the Penobscot River in trap nets and gill nets. Occasionally large schools of shad are seen in the open sea off the Maine coast, and mackerel vessels have at times made good catches in purse seines, although this fishery is necessarily uncertain. The quantity of shad taken in this State in 1889 is shown in the following table, to which the years 1880, 1887, and 1888 are added for comparison. The productiveness of each form of apparatus is given for the three more recent years. The fish credited to purse seines were of course caught by vessels and are added to make the subject complete and to afford a basis for comparison with 1880, for which year no separate figures for the shore and vessel fisheries are available.

Apparatus.	1889.		1888.		1887.		1880.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Brush weirs	6,360	$286	5,800	$273	5,700	$270	.....	.....
Pound nets	9,000	250	15,000	550	10,000	250	.....	.....
Trap nets	553,640	10,368	508,184	14,585	544,000	13,514	.....	.....
Gill nets	300,800	7,108	278,272	7,460	528,020	12,976	.....	.....
Purse seines	18,000	675	*32,000	1,500	*8,000	320	.....	.....
Total	887,800	18,687	839,256	24,368	1,095,720	27,330	580,319	$11,876

*Salted.

The following table gives, by counties and species, the quantity and value of fish taken in each form of apparatus; the invertebrates, secondary products, etc., are also added to make the presentation complete for each county. It appears that while of the fish proper the pound nets, weirs, and trap nets take by far the larger quantity, the hand lines and trawl lines yield a greater revenue. The catch in pots surpasses in value that of the lines, pound nets, weirs, etc., combined, although the quantity of fish so taken is insignificant. Examination of the table will give a comprehensive idea of the actual and relative importance of the different devices in each county.

37.—Table showing by counties and apparatus the yield of the shore fisheries of Maine in 1889.

Apparatus and species.	Washington.		Hancock.		Penobscot.		Waldo.		Knox.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Haul seines:										
Flounders, fresh			463,400	$9,135						
Smelt, fresh			53,750	5,000						
Total			517,150	14,135						
Gill nets.										
Herring, fresh	175,100	$1,475	302,207	1,206					202,500	$3,000
Herring, salted	35,000	3,900	306,325	4,307					246,000	3,300
Herring, smoked	8,000	160	3,000	120					12,500	375
Menhaden, fresh			4,800	13						
Salmon, fresh	152	25			1,853	$887				
Shad, fresh	6,000	300								
Total	224,252	5,860	616,332	5,736	1,853	887			461,000	6,675
Pound nets, weirs, and traps:										
Alewives, fresh	7,000	35	36,290	532			92,865	$480		
Alewives, salted	6,000	90	26,540	445			340	7		
Alewives, smoked			219,574	5,252			18,465	564		
Herring, fresh	5,931,525	17,858	6,149,349	22,938					2,823,750	8,662
Herring, smoked	2,968,925	92,766	193,500	6,218						
Pollock, fresh	73,500	147								
Salmon, fresh	2,043	270	65,590	15,554	330	103	70,849	14,659	3,700	840
Shad, fresh	14,000	441	2,000	107			80	3		
Smelt, fresh	33,790	859	2,275	220			1,100	110	4,000	400
Waste fish, fresh	29,400	38								
Total	9,066,183	112,504	6,695,118	51,266	330	103	183,699	15,823	2,831,450	9,902
Bag nets and dip nets:										
Alewives, fresh	22,500	150							384,250	1,537
Alewives, salted	242,600	4,236	2,700	40						
Alewives, smoked	17,800	550	6,750	180					77,500	1,550
Flounders, fresh			26,450	765			1,200	36		
Frostfish or tomcod, fresh	52,750	1,951	150,550	207	50,000	450	75,250	548		
Smelt, fresh	63,860	5,212	84,357	6,616	12,730	1,018	78,036	6,243	1,000	100
Waste fish, fresh							140,000	262		
Total	399,510	12,099	270,807	7,808	62,730	1,468	294,486	7,089	462,750	3,187
Hand lines and trawl lines:										
Cod, fresh	48,770	1,033	256,882	5,445					185,750	3,937
Cod, salted	303,210	7,741	913,921	23,334			2,000	51	124,771	3,211
Cusk, fresh			1,600	22						
Cusk, salted			17,959	182						
Hake, fresh	35,420	206	237,466	2,255			4,000	60	258,000	2,551
Hake, salted	307,650	4,614	726,738	10,900					80,239	1,206
Halibut, fresh	59,480	4,114	66,080	4,569						
Haddock, fresh	95,948	1,630	138,511	2,354			2,000	33	296,000	5,049
Haddock, salted	162,905	2,443	427,898	6,417					104,669	1,569
Pollock, fresh	21,503	225	23,600	246					30,400	314
Pollock, salted	119,991	1,250	206,755	2,160			800	8		
Smelt, fresh			150,887	12,609			5,000	400		
Total	1,154,877	23,256	3,168,297	70,493			13,800	552	1,079,829	17,837
Pots:										
Eels, fresh	1,000	95	70,325	6,296	3,500	250				
Lobsters, fresh	7,251,790	109,084	8,374,771	197,089			317,000	11,552	3,779,800	105,108
Total	7,252,790	109,179	8,445,096	203,385	3,500	250	317,000	11,552	3,779,800	105,108
Spears:										
Flounders, fresh			176,425	4,109						
Miscellaneous:										
Clams (soft), fresh	66,965	2,609	332,078	13,770			147,700	6,751	100,000	3,000
Clams (soft), salted	437,000	7,358	2,214,040	41,191			1,600	30	220,000	7,280
Scallops, fresh			177,660	11,972						
Algæ	2,500,000	1,250	4,300,000	2,015					1,450,000	725
Total	3,003,965	11,217	7,023,778	68,948			149,300	6,781	1,770,000	11,005
Secondary products:										
Sounds	9,323	233	22,022	551			121	3	2,431	61
Tongues	2,030	41	6,092	122					832	17
Oil (fish and porpoise)	35,232	1,592	76,627	2,158					23,168	637
Total	46,585	1,866	104,741	2,831			121	3	26,431	715
Grand total	21,148,162	275,981	27,017,744	428,711	68,413	2,708	958,406	41,800	10,411,260	154,429

37.—Table showing by counties and apparatus the yield of the shore fisheries of Maine in 1889—Continued.

Apparatus and species.	Lincoln.		Sagadahoc.		Cumberland.		York.		Total for State.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Haul seines:										
Flounders, fresh									463,400	$9,135
Smelt, fresh	9,000	$700			107,500	$5,180			170,250	10,880
Waste fish, fresh					99,000	505			99,000	505
Total	9,000	700			206,500	5,685			732,650	20,520
Gill nets:										
Cod, fresh							120,000	$2,950	120,000	2,950
Herring, fresh	306,000	1,910			460,000	6,770	3,400	25	1,449,207	14,476
Herring, salted	1,667,000	12,715					458,400	4,624	2,712,725	28,846
Herring, smoked									23,500	655
Mackerel, fresh			4,500	$500			21,520	2,413	26,020	2,913
Menhaden, fresh			50,000	150	1,372,500	7,230	155,600	1,120	1,582,900	8,513
Salmon, fresh									2,005	912
Shad, fresh			186,663	4,148	108,137	2,660			300,800	7,108
Total	1,973,000	14,625	241,163	4,798	1,940,637	16,660	758,920	11,132	6,217,157	66,373
Pound nets, weirs, and trap nets:										
Alewives, fresh			274,100	1,902	776,545	1,730			1,186,800	4,679
Alewives, salted									32,880	542
Alewives, smoked									238,039	5,816
Butter-fish, fresh					18,000	300	9,000	145	27,000	445
Cod, fresh							8,500	190	8,500	190
Cunners, fresh					22,000	660	2,800	53	24,800	713
Flounders, fresh							5,000	75	5,000	75
Herring, fresh	20,000	135	200,000	1,600	551,500	4,150	225,000	1,760	15,901,124	57,103
Herring, smoked									3,162,425	98,984
Mackerel, fresh			81,000	7,980	51,660	3,238	16,510	1,761	149,170	12,979
Menhaden, fresh							103,000	966	103,000	966
Pollock, fresh									73,500	147
Salmon, fresh			5,683	1,225	2,240	500	300	55	150,735	33,206
Shad, fresh			551,920	10,303			1,000	50	569,000	10,904
Smelt, fresh			4,000	200	35,000	1,800			80,165	3,589
Waste fish, fresh					180,000	950			209,400	988
Total	20,000	135	1,116,703	23,210	1,636,945	13,328	371,110	5,055	21,921,538	231,326
Fyke nets:										
Flounders, fresh	25,000	230			82,000	1,050			107,000	1,280
Frostfish, fresh			2,500	10					2,500	10
Smelt, fresh			1,500	90					1,500	90
Total	25,000	230	4,000	100	82,000	1,050			111,000	1,380
Bag nets and dip nets:										
Alewives, fresh	766,675	6,592							1,173,425	8,279
Alewives, salted	320,000	3,680							565,300	7,956
Alewives, smoked	17,625	500							119,675	2,780
Flounders, fresh									27,650	801
Frostfish, fresh			17,500	70					346,050	3,226
Smelt, fresh			23,000	1,300	13,000	800			275,983	21,289
Waste fish, fresh									140,000	262
Total	1,104,300	10,772	40,500	1,370	13,000	800			2,648,083	44,593
Hand and trawl lines:										
Bream, fresh			26,000	270					26,000	270
Catfish, fresh			6,000	120					6,000	120
Cod, fresh	576,000	12,211	65,000	1,378	565,000	11,988	536,000	11,373	2,233,402	47,365
Cod, salted	176,780	4,516							1,520,682	38,853
Cunners, fresh			16,000	585	3,300	125			19,300	710
Cusk, fresh	73,500	1,015	25,000	344	165,000	2,280	16,000	220	281,100	3,881
Cusk, salted	5,600	58							23,559	240
Flounders, fresh					10,000	160			10,000	160
Hake, fresh	542,500	5,253			968,000	9,299	175,000	1,668	2,216,366	21,252
Hake, salted	297,920	4,468							1,416,547	21,248
Halibut, fresh	7,550	520			19,000	1,311	7,800	550	159,910	11,064
Haddock, fresh	53,800	914	36,000	612	1,007,500	17,127	759,000	12,903	2,386,759	40,589
Haddock, salted	85,120	1,276							782,592	11,738
Mackerel, fresh			14,500	1,400	22,500	1,990	24,000	2,320	61,000	5,710
Pollock, fresh	49,700	497	160,000	1,820	592,300	6,340	7,000	80	884,503	9,522
Pollock, salted	56,000	582							383,546	4,000
Smelt, fresh	68,600	6,470	220,000	13,000	41,000	2,850	32,000	2,900	517,487	38,229
Total	1,993,070	37,780	568,500	19,529	3,393,600	53,470	1,556,800	32,014	12,928,773	254,931

37.—Table showing by counties and apparatus the yield of the shore fisheries of Maine in 1889—Continued.

Apparatus and species.	Lincoln.		Sagadahoc.		Cumberland.		York.		Total for State.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Pots:										
Eels, fresh									74,825	$6,641
Lobsters, fresh	1,693,250	$52,138	270,500	$8,410	2,143,900	$53,507	621,400	$19,845	24,452,111	556,733
Total	1,693,250	52,138	270,500	8,410	2,143,900	53,507	621,400	19,845	24,526,936	563,374
Spears:										
Eels, fresh	9,570	764	2,000	140	8,000	480	1,500	100	21,070	1,484
Flounders, fresh							40,000	255	216,425	4,364
Total	9,570	764	2,000	140	8,000	480	41,500	355	237,495	5,848
Miscellaneous:										
Clams (soft), fresh	92,580	3,388	59,460	1,846	1,040,009	29,869	368,280	11,126	2,207,072	72,359
Clams (soft), salted	217,400	4,725	509,000	9,620	2,478,060	54,427	104,500	2,189	6,181,600	126,820
Scallops, fresh	78,650	4,420	6,375	305					262,685	16,697
Quahogs, fresh							800	100	800	100
Algæ	1,600,000	800					3,050,000	1,525	12,900,000	6,315
Total	1,988,630	13,333	574,835	11,771	3,518,069	84,296	3,523,580	14,940	21,552,157	222,291
Secondary products:										
Sounds	9,028	226							42,925	1,074
Tongues	1,184	23							10,138	203
Oil	49,902	1,560	2,325	65	54,250	1,494	29,678	820	272,182	8,326
Total	60,114	1,809	2,325	65	54,250	1,494	29,678	820	325,245	9,603
Grand total	8,875,984	132,286	2,820,526	69,393	12,996,601	230,770	6,902,988	84,161	91,201,034	1,420,239

In the following table, based on the preceding, the wide difference in the various forms of apparatus is shown, and the disparity between the relative quantity and value of products taken in each is well exhibited. The percentage of the quantity and value of the catch in the various forms of apparatus is compared with the total yield.

38.—Table showing the relative quantity and value of yield in each principal form of apparatus of capture employed in the shore fisheries of Maine in 1889.

Apparatus.	Percentage.	
	Quantity.	Value.
Haul seines	.81	1.46
Weirs, pound nets, and trap nets	24.12	16.40
Gill nets	6.84	4.71
Fyke nets	.12	.09
Bag nets and dip nets	2.91	3.16
Hand lines and trawl lines	14.23	18.07
Pots	26.99	39.94
Spears	.26	.41
Miscellaneous	23.72	15.76
Total	100.00	100.00

From Table 39, showing certain averages and percentages, it is seen that in Penobscot County for each $100 invested in boats the fishermen take products to the value of $1,354, this being considerably more than the average for any other county, although Waldo County shows $1,020. The average value of catch per each $100 invested in apparatus is greatest in Cumberland County, being $788; after which come Lincoln, Hancock, Knox, and Washington, with over $500 each. The average catch per man is greatest in Knox County, which shows $315, against $308 in York County and $256 in Washington County. In the same table the percentage of value of yield in the principal forms of apparatus is given by counties. In Washington County it will be observed that 41 per cent of the total value of the shore fisheries is taken in pound

nets, trap nets, and weirs, and 40 per cent in pots, while only 2 per cent is taken by means of gill nets. In Hancock, Knox, and Lincoln counties pots also take by far the largest percentage of the catch. In Penobscot County seines and bag nets yield 54 per cent and gill nets 33 per cent, the relative importance of these forms of apparatus being much greater in this county than elsewhere in the State. Lines are the most important means of capture in York County, and such miscellaneous devices as rakes, hoes, dredges, etc., are most important in Cumberland County.

39.—Table showing by counties certain averages and percentages of the shore fisheries of Maine in 1889.

Counties.	Value of catch per each $100 invested in boats.	Value of catch per each $100 invested in apparatus.	Value of catch per each man employed.	Percentage of value of yield in principal forms of apparatus.								
				Total.	Pound nets, trap nets, and weirs.	Seines and bag nets.	Gill nets.	Fyke nets.	Lines.	Pots.	Spears.	Miscellaneous.
Washington	$467	$503	$256	100.00	40.76	4.38	2.12	.....	8.44	39.56	.....	4.74
Hancock	680	549	248	100.00	11.96	5.11	1.34	.....	16.45	47.44	.95	16.75
Penobscot	1,354	193	63	100.00	3.80	54.21	32.76	.....	.....	9.23	.....	.....
Waldo	1,020	339	202	100.00	37.85	16.96	.....	.....	1.32	27.64	.....	16.23
Knox	742	527	315	100.00	6.41	2.07	4.32	.....	11.55	68.06	.....	7.59
Lincoln	591	596	178	100.00	.10	8.67	11.06	.17	28.56	39.41	.58	11.45
Sagadahoc	771	276	129	100.00	33.45	1.98	6.92	.14	28.14	12.12	.20	17.05
Cumberland	573	788	209	100.00	5.78	2.81	.22	.45	23.17	23.19	.21	37.17
York	455	337	308	100.00	6.01	.....	13.23	.....	38.04	23.58	.42	18.72

The following table shows for each county the percentage of the value of each species to the value of the total yield in the county and illustrates the great differences which exist in the various counties in the matter of the importance of fish and other products therein taken:

40.—Table showing by counties the percentage of the value of each species to the total yield of the shore fisheries of Maine in 1889.

Species.	Washington.	Hancock.	Penobscot.	Waldo.	Knox.	Lincoln.	Sagadahoc.	Cumberland.	York.
Alewives, fresh	.07	.12	.....	1.15	1.00	5.05	2.74	.75	.....
Alewives, salted	1.58	.11	.....	.02	.....	2.82	.....	.....	.....
Alewives, smoked	.20	1.28	.....	1.35	1.61	.38	.....	.....	.....
Bream, fresh	.....	.....	.....	.....	.....	.....	.39	.....	.....
Butter-fish, fresh	.....	.....	.....	.....	.....	.....	.....	.13	.17
Catfish, fresh	.....	.....	.....	.....	.....	.....	.17	.....	.....
Cod, fresh	.38	1.28	.....	.....	2.56	9.36	1.99	5.23	17.42
Cod, salted	2.82	5.48	.....	.12	2.09	3.46	.....	.....	.....
Cunners, fresh	.....	.....	.....	.....	.....	.....	.84	.34	.06
Cusk, fresh	.....	.01	.....	.....	.....	.78	.50	.99	.26
Cusk, salted	.....	.04	.....	.....	.....	.04	.....	.....	.....
Eels, fresh	.03	1.48	9.23	.....	.....	.59	.20	.21	.12
Flounders, fresh	.....	3.29	.....	.09	.....	.18	.....	.53	.40
Frostfish or tomcod, fresh	.71	.05	16.62	1.31	.....	.....	.12	.....	.....
Haddock, fresh	.59	.55	.....	.08	3.28	.70	.88	7.47	15.48
Haddock, salted	.89	1.51	.....	.....	1.02	.98	.....	.....	.....
Hake, fresh	.08	.53	.....	.14	1.66	4.03	.....	4.06	2.00
Hake, salted	1.68	2.56	.....	.....	.78	3.42	.....	.....	.....
Halibut, fresh	1.50	1.07	.....	.....	.....	.40	.....	57	.66
Herring, fresh	7.05	5.69	.....	.....	7.59	1.57	2.31	4.76	2.14
Herring, salted	1.42	1.01	.....	.....	2.15	9.74	.....	.....	5.55
Herring, smoked	33.90	1.49	.....	.....	.24	.....	.....	.....	.....
Mackerel, fresh	.....	.....	.....	.....	.....	.....	14.25	2.28	7.79
Menhaden, fresh	.....	.....	.....	.....	.....	.....	.22	3.15	2.50
Pollock, fresh	.14	.06	.....	.....	.20	.38	2.63	2.77	.10
Pollock, salted	.46	.51	.....	.02	.....	.45	.....	.....	.....
Salmon, fresh	.11	3.65	36.56	35.07	.55	.....	1.77	.22	.07
Shad, fresh	.27	.03	.....	.01	.....	.....	20.84	1.16	.06
Smelt, fresh	2.22	5.74	37.59	16.15	.33	5.49	21.04	4.64	3.48
Waste fish, fresh	.01	.....	.....	.63	.....	.....	.....	.63	.....
Lobsters, fresh	39.80	46.28	.....	27.64	68.38	39.96	12.13	23.34	23.81
Clams (soft), fresh	.95	3.23	.....	16.15	1.95	2.60	2.66	13.03	13.35
Clams (soft), salted	2.68	9.67	.....	.07	4.74	3.62	13.88	23.74	2.63
Scallops, fresh	.....	2.81	.....	.....	.....	3.39	.44	.....	.....
Quahogs, fresh	.....	.....	.....	.....	.....	.....	.....	.....	.12
Algæ	.46	.47	.....	.....	.47	.61	.....	.....	1.83
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

THE SHORE INDUSTRIES.

Some of the shore fishery industries of Maine are the most important of the kind in New England, and add greatly to the value of the fisheries proper, upon which they are dependent. The branches in which the State excels all others are sardine canning, lobster canning, clam canning, and herring smoking; in addition to which the menhaden industry, preparation of finnan haddies, etc., are of considerable importance.

The canning industry.—This is the most important shore business connected with the fisheries of Maine. The different branches of the industry include the canning of sardines, menhaden, plain herring, clams, and lobsters, and mackerel when that species is obtainable. Connected with the canning business is an extensive smoked-herring trade, which is confined to Washington and Hancock counties, and is incidental to sardine canning. The full extent of the entire industry can be readily judged from the appended tables, which show the various phases of the subject in great detail.

41.—Table showing by counties the products of the canning industry of Maine in 1889.

Products.	Washington.		Hancock.		Knox.		Lincoln.		Cumberland.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.
I. Raw products:										
Herring.....pounds..	27,097,000	$77,885	3,881,000	$16,736	265,000	$1,178	35,888	$160	315,450	$2,130
Lobsters.....do....	2,451,303	30,988	1,073,323	13,258	1,772,620	22,158	455,408	5,688	.....	.....
Clams.....bushels..	.....	.....	3,011	753	10,400	2,600	4,600	1,150	12,200	3,600
Menhaden.....pounds..	.....	.....	.....	.....	881,550	2,239	.....	.....	.....	.....
Total	.....	108,873	.....	30,747	.....	28,875	.....	6,998	.....	5,730
II. Manufactured products.										
Sardines, in oil:										
Quarters .....cases..	250,957	971,204	9,683	37,473	1,300	5,200	.....	.....	.....	.....
Halves.....do....	9,881	56,716	.....	.....	.....	.....	.....	.....	.....	.....
Three-quarters..do....	1,025	4,100	.....	.....	.....	.....	.....	.....	.....	.....
Sardines, in mustard:										
Quarters .....cases..	3,127	15,635	1,000	5,000	.....	.....	.....	.....	.....	.....
Three-quarters..do....	130,096	455,336	27,973	97,906	.....	.....	.....	.....	.....	.....
Sardines, in spices:										
Quarters .....cases..	62	310	1,000	5,000	.....	.....	.....	.....	.....	.....
Three-quarters..do....	3,609	13,534	2,000	7,500	.....	.....	.....	.....	.....	.....
One pound .....do....	.....	.....	.....	.....	.....	.....	74	277	.....	.....
Two pound.....do....	.....	.....	.....	.....	.....	.....	10	26	.....	.....
Odd sizes.....do....	36	126	.....	.....	.....	.....	.....	.....	.....	.....
Sardines, in tomato sauce:										
One pound.....cases..	.....	.....	.....	.....	.....	.....	256	704	.....	.....
Two pound.....do....	.....	.....	.....	.....	.....	.....	23	58	.....	.....
"Brook trout" (herring):										
Three-pound ovals, cases	.....	.....	1,100	6,600	.....	.....	.....	.....	.....	.....
Plain herring:										
Three-quarters.cases..	643	1,608	.....	.....	.....	.....	.....	.....	.....	.....
One pound.....do....	1,812	5,074	2,200	6,160	.....	.....	76	227	2,297	6,715
Smoked herring:										
Regulars.....boxes..	261,480	40,931	32,000	4,999	.....	.....	.....	.....	.....	.....
Bloaters.....do....	13,241	10,361	.....	.....	.....	.....	.....	.....	.....	.....
Pickled herring...bbls...	616	2,464	400	1,600	.....	.....	.....	.....	.....	.....
Menhaden:										
One pound .....cans..	.....	.....	.....	.....	378,272	26,794	.....	.....	.....	.....
Russian sardines..bbls..	1,086	4,344	1,000	4,000	.....	.....	.....	.....	.....	.....
Anchovies..... do....	20	80	100	400	.....	.....	.....	.....	.....	.....
Lobsters:										
One pound.....cans..	470,348	58,794	253,601	31,700	198,621	25,659	76,951	10,424	.....	.....
Two pound.....do....	.....	.....	.....	.....	76,970	14,430	8,550	1,606	.....	.....
Clams:										
One pound .....do....	.....	.....	46,800	3,169	103,050	7,252	29,915	2,119	226,400	12,584
Two pound.....do....	.....	.....	.....	.....	18,500	1,739	9,492	889	.....	.....
Three pound ....do....	.....	.....	.....	.....	37,600	4,399	19,494	2,274	.....	.....
Clam juice.....do....	.....	.....	.....	.....	75,000	8,625	.....	.....	.....	.....
Total	.....	1,640,617	.....	211,507	.....	94,098	.....	18,604	.....	19,299
III. Secondary products:										
Oil .....gallons..	31,703	7,926	2,073	518	510	128	30	8	.....	.....
Herring pomace...tons..	1,668	13,344	240	1,920	20	160	13	104	.....	.....
Lobster pomace ...do....	980	7,840	537	4,296	669	7,065	183	1,647	.....	.....
Total	.....	29,110	.....	6,734	.....	7,353	.....	1,759	.....	.....
Total of manuf'd and secondary products..	.....	1,669,727	.....	218,241	.....	101,451	.....	20,363	.....	19,299

41.—Table showing the products of the canning industry of Maine in 1889—Continued.

SUMMARY.

Products.	No.	Value.	Products.	No.	Value.
I. Raw products:			II. Manufactured products—cont'd.		
Herring ..... pounds..	31,594,338	$98,089	Smoked herring:		
Lobsters ..... do....	5,752,654	72,092	Regulars ..... boxes..	293,480	$45,930
Clams ..... bushels.	30,211	8,103	Bloaters ..... do....	13,241	10,361
Menhaden ..... pounds..	881,550	2,939	Pickled herring ..... barrels..	1,016	4,064
			Menhaden:		
Total	.....	181,223	One pound ..... cans..	378,272	26,794
			Russian sardines ..... barrels..	2,086	8,344
II. Manufactured products:			Anchovies ..... do....	120	480
Sardines, in oil:			Lobsters:		
Quarters ..... cases..	261,940	1,013,877	One pound ..... cans..	999,521	126,577
Halves ..... do....	9,881	56,716	Two pound ..... do....	85,520	16,036
Three-quarters ..... do....	1,025	4,100	Clams:		
Sardines, in mustard:			One pound ..... do....	406,165	25,124
Quarters ..... do....	4,127	20,635	Two pound ..... do....	27,992	2,628
Three-quarters ..... do....	158,069	553,242	Three pound ..... do....	57,094	6,673
Sardines, in spices:			Clam juice ..... do....	75,000	8,625
Quarters ..... do....	1,062	5,310			
Three-quarters ..... do....	5,609	21,034	Total	.....	1,984,125
One pound ..... do....	74	277			
Two pound ..... do....	10	26	III. Secondary products:		
Odd sizes ..... do....	36	126	Oil ..... gallons..	34,316	8,580
Sardines, in tomato sauce:			Herring pomace ..... tons..	1,941	15,528
One pound ..... do....	256	704	Lobster pomace ..... do....	2,366	20,848
Two pound ..... do....	23	58			
"Brook trout" (herring):			Total	.....	44,956
Three-pound ovals ..... do....	1,100	6,600			
Plain herring:			Total manufactured and secondary products	.....	2,029,081
Three-quarters ..... do....	643	1,608			
One pound ..... do....	6,385	18,176			

42.—Summary by counties of the canning industry of Maine in 1889.

Counties.	Canneries.			No. of employés.	Value of manufactured products.
	No.	Value	Cash capital.		
Washington	31	$239,900	$442,000	3,144	$1,669,727
Hancock	9	58,600	79,500	601	218,241
Knox	4	28,000	28,250	169	101,451
Lincoln	3	9,150	9,300	94	20,363
Cumberland	2	7,800	4,000	9	19,299
Total	49	343,450	563,050	4,017	2,029,081

The combined branches are seen to have given employment to 4,017 persons; the aggregate capital invested, exclusive of boats and vessels, was $906,500; the raw products handled were worth $181,223 to the fishermen; and the manufactured goods had a market value of $2,029,081.

The canning of sardines takes first rank among the shore fishery industries. Of the forty-nine factories enumerated in the table, thirty-seven were engaged to a greater or less extent in the preparation of sardines, the value of which was greatly in excess of that of all the other manufactured products combined. The importance of this industry to the State is very great and warrants all the encouragement which can be extended. Since the last investigation of this subject was made by the U. S. Fish Commission * certain changes have taken place in the methods, etc., in the principal centers of the business, which may be properly recorded in this paper.

One of the principal items of expense in sardine canning is solder, large quantities of which are required in making and sealing the cans. Single firms annually consume

* The American Sardine Industry in 1886, by R. Edward Earll and Hugh M. Smith. Bull. U. S. Fish Commission, 1887.

over 200,000 pounds of this material, the cost price of which is over $30,000. Prior to 1889 the enormous quantities of solder utilized were in the form of bars, and the waste of material and time resulting from the use of this kind of solder was very great. In the year named nearly a dozen firms in the eastern part of the State introduced apparatus for the conversion of the bars into wire, and the use of block solder is now almost wholly discontinued in that region, the canneries having the apparatus supplying those which have not as yet introduced it. In a short time the necessary plant, which costs from $800 to $1,500, will probably be found in all the principal works. In certain canneries a change has come about in the methods of cooking fish. The ordinary ways of baking and frying give place to an endless belt 200 feet long running in a wooden casing 100 feet long, at one end of which a revolving fan forces a blast of hot air over the fish that have been spread on the belt at the other end of the tunnel. After passing along the belt once, the fish go into a bath of boiling oil, and are then treated in the usual manner. The principal advantage arising from the use of this apparatus seems to be the economy of labor, the ten or fifteen flakers required by the old method being represented by one woman who spreads the fish on the belt, and a man who turns a crank which moves the belt. The method as now practiced is clumsy, although the principle is, no doubt, a good one, and about six canneries had, up to 1889, introduced it.

One of the most important events in the history of the sardine industry in its headquarters in eastern Maine was the introduction in 1889, at Eastport, of the apparatus necessary for the decoration of the cans used in the business. Formerly this work was all done in New York, and much time was often lost in waiting for the arrival of the decorated plate; the express or freight charges were also considerable, and the arrangement was never wholly satisfactory. In the spring of 1889 a gentleman connected with a cannery in Eastport purchased the presses, dies, etc., required in this business, and announced himself as prepared to do the work as well as it could be done in New York. Some of the canners were at first skeptical and ordered their supplies as before, but by the end of the season a large majority of the packers were getting their stock from the local manufacturer, and it was thought that the following season would find all the firms patronizing the home establishment. The price charged for decorating the tin is the same as in New York, and the delay and expense of shipping are obviated.

The following tables throw additional light on the sardine business in the two easternmost counties of the State, to which the industry is almost restricted:

43.—Table showing the classification of the employés of sardine canneries in Washington and Hancock counties, Maine, in 1889, with a statement of the weekly and annual wages.

Classification of employés.	Washington.	Hancock.	Total.
Proprietors, clerks, and foremen	75	14	89
Boatmen	114	19	133
Sealers and can-makers	728	89	817
Seamers	131	19	150
Cutters and flakers, male	660	127	787
Cutters and flakers, female	467	27	494
Packers, female	548	82	630
General laborers	468	82	550
Total	3,191	459	3,650
Average weekly pay roll	$21,025	$2,605	$23,630
Total annual wages	286,476	59,000	345,476

nets, trap nets and weirs, and 40 per cent in nets, these only 2 per cent is taken by means of gill nets. In Hancock, Knox, and Lincoln counties nets also take by far the largest percentage of the catch. In Penobscot County seines and bag nets yield 54 per cent and gill nets 33 per cent, the relative importance of these forms of apparatus being much greater in this county than elsewhere in the State. Lines are the most important means of capture in York County, and such miscellaneous devices as rakes, hoes, dredges, etc., are most important in Cumberland County.

39. Table showing by counties certain averages and percentages of the shore fisheries of Maine in 1889.

County	Number of persons engaged in the fisheries	Number of boats employed	Number of nets employed	Value of apparatus	Percentage of value of total apparatus of various kinds of apparatus.							
					Seines and bag nets	Gill nets	Trap nets and weirs	Pound nets	Lines	Pots	Spears	Miscellaneous.
Washington	1167	1009	6958	60 0	40 52	4 8	2 2		5 4	9 56		4 72
Hancock	1	16	118	60 0	1 46	5 1		4	18 45	17 4	15	16 75
Penobscot	1 74	126	2	60 00	54 1	32 76				13		
Waldo	1	20	100	60 00	37 25	8 88			1 2	54 4		9 43
Knox	1	25	115	60 00	6 61	1 7	1 2		1 5	8 46		7 39
Lincoln	701	96	52	60 00	4 57	1 16			38 36	36 1	58	11 45
Sagadahoc	233	258	1200	60 00	2 15	1 98	6 62	74	38 4	12 2	29	17 95
Cumberland	57	22	100	60 00	1 71	2 81		45	23 7	13 9	1	37 17
York	455	227	940	60 00	6 81		15 25		36 04	21 56	42	18 72

The following table shows for each county the percentage of the value of each species to the value of the total yield in the county and illustrates the great differences which exist in the various counties in the matter of the importance of fish and other products therein taken:

40. Table showing by counties the percentage of the value of each species to the total yield of the shore fisheries of Maine in 1889.

Species	Washington	Hancock	Penobscot	Waldo	Knox	Lincoln	Sagadahoc	Cumberland	York
Alewives, fresh	.07	12		1.15	1.00	5.05	2.74	.75	
Alewives, salted	1.58	.11		.02		2.42			
Alewives, smoked	.20	1.28		1.45	1.61	.38			
Bream, fresh							.39		
Bullfish, fresh								.13	.17
Catfish, fresh							.17		
Cod, fresh	.38	1.78			2.56	9.38	1.99	5.23	17.42
Cod, salted	2.89	5.18		.12	2.09	3.46			
Croakers, fresh							.84	.34	.06
Cusk, fresh		.01				.78	.50	.99	.26
Cusk, salted		.04				.04			
Eels, fresh	.03	1.18	9.23			.59	.20	.21	.12
Flounders, fresh		.39		.09		.18		.53	.40
Frostfish or tomcod, fresh	.71	.05	16.62	1.31			.12		
Haddock, fresh	.59	.55		.08	3.28	.70	.88	7.47	15.48
Haddock, salted	.80	1.51			1.02	.98			
Hake, fresh	.02	.53		.14	1.66	4.03		4.06	2.00
Hake, salted	1.68	2.56			.78	3.42			
Halibut, fresh	1.50	1.07				.40		.57	.66
Herring, fresh	7.05	5.09			7.59	1.57	2.31	4.76	2.14
Herring, salted	1.12	1.01			2.15	9.74			5.55
Herring, smoked	33.00	1.49			.24				
Mackerel, fresh							14.25	2.28	7.79
Menhaden, fresh							.22	3.15	2.50
Pollock, fresh	.11	.00			.20	.38	2.63	2.77	.10
Pollock, salted	.40	.51		.02		.45			
Salmon, fresh	.11	2.05	30.50	85.07	.55		1.77	.22	.07
Shad, fresh	2.27	.03		.01			20.84	1.16	.06
Smelt, fresh	2.32	5.74	37.50	10.15	.33	5.49	21.04	4.64	3.48
Weakfish, fresh	.01			.03				.63	
Lobsters, fresh	30.80	40.28		27.04	68.38	30.00	12.13	24.34	23.81
Clams (soft), fresh	.05	3.23		10.15	1.95	2.00	2.66	13.03	13.35
Clams (soft), salted	2.08	9.07		.07	4.74	3.62	13.88	23.74	2.63
Scallops, fresh		2.81				3.39	.44		
Quahaugs, fresh									.12
Eggs	.40	.47			.47	.01			1.83
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The quantities of fish smoked by the fishermen themselves and at the sardine canneries are shown separately in the following statement. In the regular tables for this State only the herring taken in United States waters and smoked by our fishermen have been returned as smoked, while the American-caught fish that were smoked at the sardine canneries appear as such in the statistics of that industry, but in the products tables are included under fresh herring for the reason that the fish left the hands of the fishermen in a fresh condition.

47.—Table showing the quantities of smoked herring prepared by the fishermen and sardine-canners of Maine in 1889.

Designation.	Boxes.	Pounds.	Value.
Smoked by fishermen—			
Regular size	626,400	3,132,000	$98,031
Bloaters	6,400	160,000	5,008
Total	632,800	3,292,000	103,039
Smoked by sardine canners—			
Regular size	293,480	1,467,400	45,930
Bloaters	13,241	331,025	10,361
Total	306,721	1,798,425	56,291
Grand total	939,521	5,090,425	159,330

For purposes of comparison the quantities of herring smoked in 1880, 1887, 1888, and 1889 are here given in one table. The annual increase since 1885 is very marked.

48.—Comparative table showing the quantity of herring smoked in Maine in 1880, 1887, 1888, and 1889.

Years.	Regular size.			Bloaters.			Total.		
	Boxes.	Pounds.	Value.	Boxes.	Pounds.	Value.	Boxes.	Pounds.	Value.
1880	318,915	2,710,778	$63,783	51,700	1,723,333	$36,190	370,615	4,434,111	$99,973
1887	588,297	2,941,485	88,506	19,120	478,000	11,982	607,417	3,419,485	100,488
1888	755,077	3,775,385	124,705	23,402	585,050	15,449	778,479	4,360,435	140,154
1889	919,880	4,599,400	143,961	19,641	491,025	15,369	939,521	5,090,425	159,330

NOTE.—In 1880 the average weight of a box of regular-size herring was 8½ pounds and of bloaters 33¼ pounds. Since that year there appears to have been a decrease in the size of boxes used, for in 1889 the average net weight of fish in the ordinary boxes was 5 pounds and in the larger boxes 25 pounds.

The menhaden industry.—The return of menhaden to the waters of Maine has caused the revival of an industry which formerly was of great value to the State. Already the capital devoted to it amounts to $112,015, and it seems probable that the near future will give evidence of a still more marked increase in the business. The details of the industry as it existed in 1889 are shown in Table 49.

49.—Table showing the extent of the menhaden industry of Maine.

Designation.	1889.	Designation.	1889.
Number of factories in operation	3	Number of sailing vessels employed	13
Value of factories	$22,200	Net tonnage	398.10
Amount of cash capital	$20,000	Value	$15,950
Number of shoresmen employed	104	Value of outfit	$13,065
Number of fishermen employed	195	Number of menhaden handled	*26,057,583
Number of steam vessels employed	4	Value to fishermen	$31,269
Net tonnage	218.22	Number of gallons of oil made	282,465
Value	$32,000	Value as sold	$62,409
Value of outfit	$8,800	Number of tons of scrap produced	2,305
		Value as sold	$24,735

*This number represents considerable quantities taken by vessels owned in other States and is larger than the aggregate catch of menhaden by citizens of Maine.

41.—Table showing the products of the canning industry of Maine in 1889—Continued.

SUMMARY.

Products.	No.	Value.	Products.	No.	Value.
I. Raw products:			II. Manufactured products—cont'd.		
Herring ..... pounds..	31,594,338	$98,089	Smoked herring:		
Lobsters ..... do....	5,752,654	72,092	Regulars ..... boxes..	293,480	$45,930
Clams ..... bushels.	30,211	8,103	Bloaters ..... do....	13,241	10,361
Menhaden ..... pounds..	881,550	2,939	Pickled herring ..... barrels..	1,016	4,064
Total	.....	181,223	Menhaden:		
II. Manufactured products:			One pound ..... cans..	378,272	26,794
Sardines, in oil:			Russian sardines ..... barrels..	2,086	8,344
Quarters ..... cases..	261,940	1,013,877	Anchovies ..... do....	120	480
Halves ..... do....	9,881	56,716	Lobsters:		
Three-quarters ..... do....	1,025	4,100	One pound ..... cans..	999,521	126,577
Sardines, in mustard:			Two pound ..... do....	85,520	16,036
Quarters ..... do....	4,127	20,635	Clams:		
Three-quarters ..... do....	158,069	553,242	One pound ..... do....	406,165	25,124
Sardines, in spices:			Two pound ..... do....	27,992	2,628
Quarters ..... do....	1,062	5,310	Three pound ..... do....	57,094	6,673
Three-quarters ..... do....	5,609	21,034	Clam juice ..... do....	75,000	8,625
One pound ..... do....	74	277	Total	.....	1,984,125
Two pound ..... do....	10	26	III. Secondary products:		
Odd sizes ..... do....	36	126	Oil ..... gallons..	34,316	8,580
Sardines, in tomato sauce:			Herring pomace ..... tons..	1,941	15,528
One pound ..... do....	256	704	Lobster pomace ..... do....	2,366	20,848
Two pound ..... do....	23	58	Total	.....	44,956
"Brook trout" (herring):					
Three-pound ovals ..... do....	1,100	6,600	Total manufactured and secondary products	.....	2,029,081
Plain herring:					
Three-quarters ..... do....	643	1,608			
One pound ..... do....	6,385	18,176			

42.—Summary by counties of the canning industry of Maine in 1889.

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	No.	Value	Cash capital.		
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One of the most important events in the history of the sardine industry in its headquarters in eastern Maine was the introduction in 1889, at Eastport, of the apparatus necessary for the decoration of the cans used in the business. Formerly this work was all done in New York, and much time was often lost in waiting for the arrival of the decorated plate; the express or freight charges were also considerable, and the arrangement was never wholly satisfactory. In the spring of 1889 a gentleman connected with a cannery in Eastport purchased the presses, dies, etc., required in this business, and announced himself as prepared to do the work as well as it could be done in New York. Some of the canners were at first skeptical and ordered their supplies as before, but by the end of the season a large majority of the packers were getting their stock from the local manufacturer, and it was thought that the following season would find all the firms patronizing the home establishment. The price charged for decorating the tin is the same as in New York, and the delay and expense of shipping are obviated.

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Seamers	131	19	150
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Cutters and flakers, female	467	27	494
Packers, female	548	82	630
General laborers	468	82	550
Total	3,191	459	3,650
Average weekly pay roll	$21,025	$2,605	$23,630
Total annual wages	286,476	59,000	345,476

44.—Table showing the number and value of supply boats employed in the sardine industry of Washington and Hancock counties, Maine, in 1889.

Designation.	Washington.		Hancock.		Total.	
	No.	Value.	No.	Value.	No.	Value.
Steamers	4	$10,700	2	$5,000	6	$15,700
Sailboats	61	16,330	9	2,800	70	19,130
Total	65	27,030	11	7,800	76	34,830

The laws of the State permit the canning of lobsters only during the months of May and June, and fix the minimum size of lobsters used for canning at 9 inches. Lobster-canning in the easternmost counties of the State is done at regular sardine canneries, most of the apparatus and accessories being jointly used in the preparation of these products. The table shows 20 canneries in operation in 1889, employing 577 persons in various capacities. The canned goods were valued at $142,613. The employés shown in the following table are such as were employed in the lobster-canning business, although practically all of those in the first two counties were also engaged in canning sardines. The object of the table is to exhibit the extent of the lobster-canning trade without reference to other associated industries.

45.—Table showing the extent of the lobster-canning industry of Maine in 1889.

Counties.	No. of canneries in operation.	No. of employés.	Lobsters utilized.		Cans prepared.	
			Pounds.	Value.	Number.	Value.
Washington	7	177	2,451,303	$30,988	470,348	$58,794
Hancock	6	157	1,073,323	13,258	253,601	31,700
Knox	4	149	1,772,620	22,158	275,591	40,089
Lincoln	3	94	455,408	5,688	85,501	12,030
Total	20	577	5,752,654	72,092	1,085,041	142,613

Smoked-herring industry.—The smoking of herring in eastern Maine had almost become an extinct business at the time of the abrogation of the fishery clauses of the Washington treaty. Since 1885 the industry has advanced year by year, and in 1889 was probably more extensive than ever before known. The extent of the industry in 1889 is well exhibited in the following table, in which separate figures are shown for the smoked goods prepared from herring taken in American and Canadian weirs:

46.—Table showing the extent of the smoked-herring industry of Maine in 1889.

Designation.	Boxes.	Pounds.	Value.
Caught in Maine weirs—			
Regular size	534,280	2,671,400	$83,615
Bloaters	19,641	491,025	15,369
Total	553,921	3,162,425	98,984
Caught in Canadian weirs—			
Regular size	385,600	1,928,000	60,346
Bloaters			
Total	385,600	1,928,000	60,346
Grand total	939,521	5,090,425	159,330

THE SHORE FISHERIES.

The shore fisheries of New Hampshire yield about one-half as much products as the vessel fisheries and rather more than half the value of the latter. The 194 shore fishermen have $4,170 invested in boats and $5,626 in apparatus, as shown in the second table for the State, and in 1889 took the following products:

57.—Table showing by species the yield of the shore fisheries of New Hampshire in 1889.

Species.	Pounds.	Value.	Species.	Pounds.	Value.
Alewives, fresh	140,400	$3,080	Sea bass, fresh	500	$40
Cod, fresh	435,400	7,240	Shad, fresh	88	3
Eels, fresh	12,000	1,200	Smelt, fresh	46,000	3,600
Haddock, fresh	644,000	10,250	Miscellaneous fish, fresh	10,000	300
Herring, fresh	19,800	195	Lobsters, fresh	123,000	5,770
Mackerel, fresh	2,160	240	Clams (soft), fresh	3,000	150
Menhaden, fresh	37,000	225			
Perch or cunners, fresh	4,000	200	Total	1,477,348	32,493

The foregoing table shows that the average value of the products taken by the shore fishermen of New Hampshire is $167 per man, $774 per each $100 invested in boats, and $580 per each $100 invested in apparatus. It is also seen that 32 per cent of the income of the shore fishermen is obtained from the sale of haddock, 22 per cent from cod, 17 per cent from lobsters, 11 per cent from smelt, 9 per cent from alewives, 4 per cent from eels, and 1 per cent each from mackerel, menhaden, herring, perch, and minor species.

The importance of the various fishing devices employed in the shore fisheries of the State is exhibited in the following table, in which the quantity and value of each species taken in each form of apparatus are given.

58.—Table showing by apparatus and species the yield of the shore fisheries of New Hampshire in 1889.

Apparatus and species.	Pounds.	Value.	Apparatus and species.	Pounds.	Value.
Weirs:			Trawl lines and hand lines:		
Alewives, fresh	133,200	$2,960	Cod, fresh	435,400	$7,240
Perch, fresh	4,000	200	Haddock, fresh	644,000	10,250
Sea bass, fresh	500	40	Smelt, fresh	45,000	3,500
Shad, fresh	88	3	Miscellaneous, fresh	10,000	300
Smelt, fresh	1,000	100			
Total	138,788	3,303	Total	1,134,400	21,290
Seines:			Spears:		
Alewives, fresh	7,200	120	Eels, fresh	12,000	1,200
Gill nets:			Miscellaneous:		
Herring, fresh	19,800	195	Lobsters	123,000	5,770
Mackerel, fresh	2,160	240	Clams (soft)	3,000	150
Menhaden, fresh	37,000	225	Total	126,000	5,920
Total	58,960	660	Grand total	1,477,348	32,493

Examination of the table shows that lines are to be credited with 65 per cent of the stock, weirs with 10 per cent, spears with 4 per cent, gill nets with 2 per cent, seines with 1 per cent, and pots and other minor apparatus with 18 per cent.

The salmon.—This, the most highly esteemed of the food-fishes of Maine, is chiefly abundant in the Penobscot River, in which more than seven-eighths of the yield is taken. Practically, the entire catch is obtained in weirs and trap nets. The preservation of the salmon in the State is largely dependent on the artificial stocking of the streams by the introduction of fry hatched at the Government stations on the Penobscot. The catch varies considerably from year to year, and in 1889 was less than in the two preceding years, being 152,740 pounds, against 185,637 pounds in 1887 and 205,149 pounds in 1888. The yield in 1889 was worth $34,118, giving the fish an average value of 29 cents a pound.

The shad.—The catch of shad in Maine waters is now greater than in any other New England State, although in 1880 the output of the Connecticut fishery was more than double that of Maine. The fishery has undergone a considerable advance since 1880 and is no doubt still capable of great development. Almost the entire yield is taken west of the Penobscot River in trap nets and gill nets. Occasionally large schools of shad are seen in the open sea off the Maine coast, and mackerel vessels have at times made good catches in purse seines, although this fishery is necessarily uncertain. The quantity of shad taken in this State in 1889 is shown in the following table, to which the years 1880, 1887, and 1888 are added for comparison. The productiveness of each form of apparatus is given for the three more recent years. The fish credited to purse seines were of course caught by vessels and are added to make the subject complete and to afford a basis for comparison with 1880, for which year no separate figures for the shore and vessel fisheries are available.

Apparatus.	1889.		1888.		1887.		1880.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Brush weirs	6,360	$286	5,800	$273	5,700	$270	.....	.....
Pound nets	9,000	250	15,000	550	10,000	250	.....	.....
Trap nets	553,640	10,368	508,184	14,585	544,000	13,514	.....	.....
Gill nets	300,800	7,108	278,272	7,460	528,020	12,976	.....	.....
Purse seines	18,000	675	*32,000	1,500	*8,000	320	.....	.....
Total	887,800	18,687	839,256	24,368	1,095,720	27,330	580,319	$11,876

*Salted.

The following table gives, by counties and species, the quantity and value of fish taken in each form of apparatus; the invertebrates, secondary products, etc., are also added to make the presentation complete for each county. It appears that while of the fish proper the pound nets, weirs, and trap nets take by far the larger quantity, the hand lines and trawl lines yield a greater revenue. The catch in pots surpasses in value that of the lines, pound nets, weirs, etc., combined, although the quantity of fish so taken is insignificant. Examination of the table will give a comprehensive idea of the actual and relative importance of the different devices in each county.

61.—Table of products.

Species.	Vessel fisheries.		Shore fisheries.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Albacore, fresh			74,700	$291	74,700	$291
Alewives, fresh			2,032,691	29,173	2,032,691	29,173
Alewives, salted	6,600	$66	1,245,350	22,216	1,251,950	22,282
Bluefish, fresh	74,954	5,111	322,013	28,675	396,967	33,786
Bonito, fresh			194,066	8,157	194,066	8,157
Bonito, salted			1,400	88	1,400	88
Butter-fish, fresh	6,000	180	756,438	22,928	762,438	23,108
Cod, fresh	19,413,205	475,761	1,692,508	32,105	21,105,713	507,866
Cod, salted	54,698,109	1,487,218	538,179	17,814	55,236,288	1,505,032
Cunners, fresh	80,000	1,120	348,095	17,668	428,095	18,788
Cusk, fresh	431,778	4,932			431,778	4,932
Cusk, salted	399,405	6,853			399,405	6,853
Eels, fresh			424,708	24,295	424,708	24,295
Flounders, fresh	10,854	217	946,919	20,749	957,773	20,966
Frostfish or tomcod, fresh			4,873	113	4,873	113
Grouper, fresh	16,838	269			16,838	269
Haddock, fresh	33,832,526	580,723	775,511	11,450	34,608,037	592,173
Haddock, salted	697,380	9,593			697,380	9,593
Hake, fresh	4,875,506	51,445	622,800	4,245	5,498,306	55,690
Hake, salted	855,198	12,242			855,198	12,242
Halibut, fresh	8,913,260	611,640	200	14	8,913,460	611,654
Halibut, salted	974,930	48,932			974,930	48,932
Herring, fresh	273,390	2,334	7,647,088	63,888	7,920,478	66,222
Herring, salted	956,800	13,434	1,054,100	11,106	2,010,900	24,540
Hickory shad			8,640	219	8,640	219
Kingfish, fresh			4,241	353	4,241	353
Mackerel, fresh	992,151	90,364	1,312,877	99,710	2,305,028	190,074
Mackerel, salted	4,148,100	371,153	234,067	23,364	4,382,167	394,517
Menhaden, fresh	1,629,606	8,679	574,336	3,977	2,203,936	12,656
Menhaden, salted	167,200	2,872	3,600	72	170,800	2,944
Pollock, fresh	2,937,438	30,278	155,000	1,623	3,092,438	31,901
Pollock, salted	1,967,421	23,448	9,380	109	1,976,801	23,557
Red snapper, fresh	211,156	6,057			211,156	6,057
Salmon, fresh			139	66	139	66
Scup, fresh	27,733	829	2,473,432	81,824	2,501,165	82,653
Sea bass, fresh	23,067	1,503	791,017	55,292	814,084	56,795
Shad, fresh	67,200	2,036	43,524	1,926	110,724	3,962
Shad, salted	120,800	3,302	2,800	104	123,600	3,406
Spanish mackerel, fresh	20,000	1,600	3,461	873	23,461	2,473
Smelt, fresh			10,700	1,098	10,700	1,098
Squeteague, fresh			216,571	10,929	216,571	10,929
Striped bass, fresh			24,878	2,669	24,878	2,669
Sturgeon, fresh			2,800	132	2,800	132
Swordfish, fresh	232,424	10,207	15,400	843	247,824	11,050
Swordfish, salted	7,200	334			7,200	334
Tautog, fresh	33,972	2,055	612,393	22,310	646,365	24,365
Whiting, fresh			114,449	1,399	114,449	1,399
Miscellaneous fish, fresh	2,200	44	4,367	110	6,567	154
Miscellaneous fish, salted	54,200	696			54,200	696
Refuse fish, fresh			1,024,400	1,093	1,024,400	1,093
Squid, fresh			567,800	4,466	567,800	4,466
Shrimp, fresh			2,365	860	2,365	860
Lobsters, fresh	80,225	3,836	3,273,562	144,656	3,353,787	148,492
Oysters, fresh			258,867	65,538	[a]258,867	65,538
Clams (soft), fresh	6,800	664	2,236,510	123,283	[b]2,243,310	123,947
Clams (soft), salted			274,920	13,764	[c]274,920	13,764
Quahogs, fresh			135,304	12,549	[d]135,304	12,549
Scallops, fresh	14,875	2,905	102,357	23,869	[e]117,232	26,774
Halibut fins, salted	62,000	2,754			62,000	2,754
Sounds	43,933	1,316			43,933	1,316
Tongues	251,383	5,026			251,383	5,026
Oil, fish	2,160,309	77,768			[f]2,160,309	77,768
Oil, whale	6,171,518	488,524			[g]6,171,518	488,524
Ambergris	37	7,750			37	7,750
Whalebone	98,268	320,115			98,268	320,115
Algæ			117,993,900	66,034	117,993,900	66,034
Total	148,047,973	4,778,185	151,169,696	1,080,089	299,217,669	5,858,274

[a] 36,981 bushels. [b] 224,331 bushels. [c] 1,375 barrels. [d] 16,913 bushels.
[e] 33,495 bushels. [f] 288,041 gallons. [g] 822,869 gallons.

THE VESSEL FISHERIES.

The vessels employed in the fisheries of Massachusetts are chiefly distinguished for their relatively high value and large size. Those engaged in the food fisheries are the best of their class in the country. The fishing fleet is much more numerous and important than in any other New England State; and, with the exception of Maryland, Massachusetts has a larger number of fishing vessels than any other State.

Statistics of the vessel fisheries are exhibited from the following points of view: By counties, by customs districts, by apparatus, by fishing-grounds, and by fisheries.

There are seven counties in Massachusetts from which vessel fishing is now carried on; these are Essex, Suffolk, Plymouth, Barnstable, Nantucket, Dukes, and Bristol. The extent of the industry in each is clearly shown in the following tables.

The first table indicates that of the 10,760 persons employed on the fishing fleet of Massachusetts, 5,729 are on vessels belonging in Essex County, in which is situated the great fishing port of Gloucester, and 2,295 on vessels in Barnstable County, while only 13 vessel fishermen are credited to Plymouth County. Vessels engaged in transporting fishery products carried 91 men, of whom 42 were in Barnstable County and 22 in Essex County.

The first table also gives the number of Americans, British provincials, and other foreigners constituting the crews of the fishing vessels of Massachusetts. As already stated, this is one of the most important questions connected with the fishery marine of New England; it is also one which has been the subject of much misstatement and misapprehension. The table shows that of the 10,851 persons on the fishing vessels of Massachusetts in 1889, 8,002, or 73.7 per cent, were American citizens, 1,157, or 10.7 per cent, were British provincials, and 1,692, or 15.6 per cent, were subjects of other countries. The general tendency among fishermen of foreign birth, so far as information can be obtained, is to become naturalized, marry, and acquire homes at the various fishing ports; many of them own the whole or part of the vessels in which they sail.

The second table of this series shows that $5,335,602 was invested in the vessel fisheries of Massachusetts in 1889, of which sum $2,858,250, or more than half, is credited to Essex County, and $1,136,250 to Bristol County. The former county had 442 fishing vessels, or considerably more than half of the fishing fleet of the State, followed by Barnstable County with 188, and Bristol County with 80. The vessels employed in transporting numbered 22, of which 10 were in Barnstable County. Trawl lines and hand lines are the most widely adopted and important apparatus employed in the vessel fisheries of the State; the quantity used in 1889 was valued at over $550,000. Seines to the number of 235, worth $120,600, were carried by mackerel vessels, chiefly in Essex, Barnstable, and Suffolk counties. Gill nets, the next important means of capture, are fished chiefly in Essex and Barnstable counties, in which 988 of the total number operated, viz, 1,049, were owned. The minor apparatus carried by the vessels of Massachusetts consists of snap nets, harpoons, pots, rakes, and dredges. The devices used in the whale fishery are of such a miscellaneous nature that it has not been found practicable to classify them or show them separately under the head of apparatus. Their value has been included with that of the outfit of the vessels in the tables.

The vessel fisheries of Massachusetts are seen to have yielded 148,047,973 pounds in 1889, of which the value at first hands was $4,778,185. The most important single product was the cod, of which 74,111,314 pounds, worth $1,962,979, were obtained. No other species was valued as high as $1,000,000, and the combined value of the various products of the whale fishery was only $816,389. The great relative and actual importance of the cod is thus clearly indicated. The next most prominent species are the halibut, 9,888,190 pounds, valued at $660,572; the haddock, 34,529,906 pounds, worth $590,316; and the mackerel, 5,140,251 pounds, worth $461,547.

62.—Table showing by counties the number and nationality of men employed in the vessel fisheries of Massachusetts in 1889.

Counties.	Number and nationality of men on fishing vessels.				Number and nationality of men on transporting vessels.			
	Americans.	British provincials.	All others.	Total.	Americans.	British provincials.	All others.	Total.
Essex	5,133	298	298	5,729	22	.....	.....	22
Suffolk	573	66	143	782	10	.....	.....	10
Plymouth	13	.....	.....	13	.....	.....	.....	.....
Barnstable	1,327	497	471	2,295	42	.....	.....	42
Nantucket	32	.....	.....	32	.....	.....	.....	.....
Dukes	94	16	15	125	4	.....	.....	4
Bristol	739	280	765	1,784	13	.....	.....	13
Total	7,911	1,157	1,692	10,760	91	.....	.....	91

63.—Table showing by counties the number and value of vessels and apparatus employed in the vessel fisheries of Massachusetts in 1889.

Counties.	Vessels.							
	Fishing.				Transporting.			
	No.	Net tonnage.	Value.	Value of outfit.	No.	Net tonnage.	Value.	Value of outfit.
Essex	442	28,380.54	$1,653,800	$714,612	4	322.12	$14,800	$1,000
Suffolk	66	3,678.29	201,820	68,673	2	113.92	4,500	600
Plymouth	2	55.85	2,400	1,390	.....	.....	.....	.....
Barnstable	188	11,786.22	522,250	241,357	10	479.40	21,500	2,075
Nantucket	16	109.65	7,000	619	.....	.....	.....	.....
Dukes	20	642.78	24,900	19,220	2	21.07	2,400	250
Bristol	80	13,330.85	630,575	487,527	4	338.61	12,400	3,500
Total	814	57,984.18	3,042,745	1,533,398	22	1,275.12	55,600	7,425

Counties.	Apparatus of capture.														
	Seines.		Gill nets.		Snap nets.		Trawl lines and hand lines.		Pots.		Harpoons.*		Dredges and rakes.		Total investment.
	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.	
Essex	155	$77,500	468	$5,285	.....	.....	.....	$390,433	450	$550	36	$270	.....	.....	$2,858,250
Suffolk	21	10,500	44	656	27	$73	....	71,405	500	800	4	30	.....	.....	359,057
Plymouth	.....	.....	.....	.....	.....	.....	.....	135	.....	.....	.....	.....	.....	.....	3,925
Barnstable	57	31,950	520	4,718	.....	.....	.....	98,430	.....	.....	8	60	.....	.....	922,340
Nantucket	.....	.....	.....	.....	.....	.....	.....	205	.....	.....	.....	.....	24	$96	7,920
Dukes	1	150	14	650	.....	.....	.....	141	.....	.....	16	120	10	29	47,860
Bristol	1	500	3	150	.....	.....	.....	997	250	250	44	330	8	21	1,136,250
Total	235	120,600	1,049	11,459	27	73	....	561,746	1,200	1,600	108	810	42	146	5,335,602

* The harpoons here enumerated were those used for the capture of swordfish.

64.—Table showing by counties and species the yield of the vessel fisheries of Massachusetts in 1889.

Species.	Essex.		Suffolk.		Plymouth.		Barnstable.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives, salted	6,600	$66						
Bluefish, fresh							24,927	$1,521
Butter-fish, fresh	6,000	180						
Cod, fresh	9,567,201	215,959	4,077,470	$103,978	96,500	$1,875	5,594,012	151,441
Cod, salted	46,443,153	1,224,557	1,695,370	39,295			6,376,986	217,611
Cunners, fresh			80,000	1,120				
Cusk, fresh	263,122	2,987	75,456	756			93,200	1,189
Cusk, salted	399,405	6,853						
Flounders, fresh							7,600	152
Groupers, fresh			16,868	269				
Haddock, fresh	17,401,875	322,946	10,304,670	157,956	94,500	1,580	6,028,281	98,174
Haddock, salted	684,380	9,463					13,000	130
Hake, fresh	1,870,083	20,866	1,678,523	16,787	1,900	20	1,325,000	13,772
Hake, salted	855,198	12,242						
Halibut, fresh	8,244,048	554,013	190,956	18,776			478,256	38,851
Halibut, salted	974,930	48,932						
Herring, fresh	211,200	1,951	60,750	377			1,440	6
Herring, salted	699,800	9,915	245,000	3,369			12,000	150
Mackerel, fresh	584,040	48,976	252,976	27,458	41,100	4,110	98,704	8,626
Mackerel, salted	2,786,200	256,490	222,000	21,004			1,015,600	84,246
Menhaden, fresh	269,000	1,385	68,600	344			1,200,000	6,000
Menhaden, salted	167,200	2,872						
Pollock, fresh	2,325,004	23,278	94,334	1,660			518,100	5,340
Pollock, salted	1,516,066	17,401	255	3			451,100	6,044
Red snapper, fresh	120,000	3,600	91,156	2,457				
Shad, fresh	41,400	1,616	6,000	180			19,800	240
Shad, salted	26,000	780					94,800	2,522
Spanish mackerel, fresh	20,000	1,600						
Swordfish, fresh	108,958	5,305	9,100	344			12,700	419
Swordfish, salted	4,800	250						
Tautog, fresh							15,000	1,100
Miscellaneous fish, fresh							2,200	44
Miscellaneous fish, salted	54,200	696						
Lobsters	37,500	1,635	13,500	666				
Clams (soft)	6,400	614						
Halibut fins	62,000	2,754						
Sounds	23,911	716	11,189	335			8,833	265
Tongues	213,929	4,278	7,706	154			28,986	579
Oil, fish	1,456,287	52,425	335,019	12,060			364,854	13,134
Oil, whale			48,750	4,225			504,263	42,655
Whalebone							1,200	84
Total	97,449,890	2,857,601	19,585,648	413,576	234,000	7,585	24,290,842	694,295

Species.	Nantucket.		Dukes.		Bristol.		Total for State.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives, salted							6,600	$66
Bluefish, fresh	20,000	$1,600	28,427	$1,862	1,600	$128	74,954	5,111
Butter-fish, fresh							6,000	180
Cod, fresh	15,000	375	10,722	362	52,300	1,771	19,413,205	475,761
Cod, salted	15,000	600			167,600	5,155	54,698,109	1,487,218
Cunners, fresh							80,000	1,120
Cusk, fresh							431,778	4,932
Cusk, salted							399,405	6,853
Flounders, fresh			3,254	65			10,854	217
Groupers, fresh							16,868	269
Haddock, fresh			3,200	64			33,832,526	580,723
Haddock, salted							697,380	9,593
Hake, fresh							4,875,506	51,445
Hake, salted							855,198	12,242
Halibut, fresh							8,913,260	611,640
Halibut, salted							974,930	48,932
Herring, fresh							273,390	2,334
Herring, salted							956,800	13,434
Mackerel, fresh	8,000	800	6,331	294	1,000	100	992,151	90,364
Mackerel, salted	5,000	500	14,100	1,122	105,200	7,791	4,148,100	371,153
Menhaden, fresh			32,000	800	60,000	150	1,629,600	8,679
Menhaden, salted							167,200	2,872
Pollock, fresh							2,937,438	30,278
Pollock, salted							1,967,421	23,448
Red snapper, fresh							211,156	6,057
Sea bass, fresh			23,067	1,503			23,067	1,503
Scup, fresh			16,900	431	10,833	398	27,733	829
Shad, fresh							67,200	2,036
Shad, salted							120,800	3,302
Spanish mackerel, fresh							20,000	1,600
Swordfish, fresh			25,466	1,022	76,206	3,117	232,424	10,207

64.—Table showing by counties and species the yield of the vessel fisheries of Massachusetts in 1889—Cont'd.

Species.	Nantucket.		Dukes.		Bristol.		Total for State.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Swordfish, salted			2,400	$84			7,200	$334
Tautog, fresh					18,972	$955	33,972	2,055
Miscellaneous fish, fresh							2,200	44
Miscellaneous fish, salted							54,200	690
Lobsters					29,225	1,535	80,225	3,836
Clams (soft)			400	50			6,800	664
Scallops	7,000	$1,400	7,175	1,305	700	200	14,875	2,905
Halibut fins							62,000	2,754
Sounds							43,933	1,316
Tongues					762	15	251,383	5,026
Oil, fish					4,149	149	2,160,309	77,768
Oil, whale			161,025	14,084	5,457,480	427,560	6,171,518	488,524
Ambergris					37	7,750	37	7,750
Whalebone					97,068	320,031	98,268	320,115
Total	70,000	5,275	334,467	23,048	6,083,126	776,805	148,047,973	4,778,185

Certain averages which throw considerable light on the vessel fisheries of the various counties are given in the following table. The greatest average tonnage is found in Bristol County, in which the whaling vessels constitute a prominent part of the fishing fleet; in Nantucket County, where the shore fishery with lines and nets is the principal branch, the vessels have the least average tonnage; the extremes, as represented by these two counties, are 166.64 and 6.85 tons, respectively. The average value per ton is, singularly enough, greatest in Nantucket County and least in Bristol County. Among the important fishing counties, the average value per ton is greatest in Essex County. The average value of vessels is naturally greatest in Bristol County, in which the vessels are largest, after which comes Essex County. The same statement applies to the average value of apparatus and outfit and the average number of crew. The average value of catch per man is highest in Plymouth County and lowest in Nantucket County. After Plymouth come Suffolk, Essex, and Bristol. In the average stock per vessel Bristol County takes considerable precedence over any other, with $9,710; then come Essex with $6,465 and Suffolk with $6,266. For each ton employed Plymouth County in 1889 took products to the value of $136, Suffolk County $112, and Essex County $101. For each $100 invested in the vessel fisheries the last-named county also took products worth $101, while Plymouth County is credited with $194 and Suffolk County with $117.

65.—Table showing by counties certain average figures for the vessels employed in the fisheries of Massachusetts in 1889.

Counties.	Net tonnage.	Value per ton.	Value per vessel.	Value of apparatus and outfit.	No. of men to vessel.	Value of catch per man.	Value of catch per vessel.	Value of catch per each ton employed.	Value of catch per each $100 invested in fishing vessels.
Essex	64.21	$58	$3,742	$2,689	13	$499	$6,465	$101	$101
Suffolk	55.73	55	3,058	2,305	12	529	6,266	112	117
Plymouth	27.93	43	1,200	763	7	583	3,793	136	194
Barnstable	62.69	44	2,778	2,003	12	302	3,693	59	77
Nantucket	6.85	64	438	58	2	165	330	48	67
Dukes	32.14	39	1,245	1,016	6	184	1,152	36	51
Bristol	166.64	47	7,882	6,122	22	435	9,710	58	69

The comparative importance of each of the principal fishery products in the various counties is shown in the next table. The figures represent the percentage of the value of each species to the total yield in each county.

66.—Table showing by counties the percentage of value of each species or product taken in the vessel fisheries of Massachusetts in 1889.

Species.	Essex.	Suffolk.	Plymouth.	Barnstable.	Nantucket.	Dukes.	Bristol.
Alewives, salted	[.002]						
Bluefish, fresh				.22	30.33	8.08	.02
Butter-fish, fresh	.01						
Cod, fresh	7.56	25.14	24.72	21.81	7.11	1.57	.23
Cod, salted	42.85	9.50		31.34	11.37		.66
Cunners, fresh		.27					
Cusk, fresh	.10	.18		.17			
Cusk, salted	.24						
Flounders, fresh				.02		.28	
Groupers, fresh		.07					
Haddock, fresh	11.30	38.19	20.83	14.14		.28	
Haddock, salted	.33			.02			
Hake, fresh	.73	4.06	.26	1.98			
Hake, salted	.43						
Halibut, fresh	19.39	4.54		5.60			
Halibut, salted	1.71						
Herring, fresh	.07	.09					
Herring, salted	.35	.82		.02			
Mackerel, fresh	1.71	6.64	54.19	1.24	15.17	1.28	.01
Mackerel, salted	8.97	5.08		12.14	9.48	4.87	1.00
Menhaden, fresh	.05	.08		.87		3.47	.02
Menhaden, salted	.10						
Pollock, fresh	.81	.40		.77			
Pollock, salted	.61			.87			
Red snapper, fresh	.13	.60					
Sea bass, fresh						6.52	
Scup, fresh						1.87	.05
Shad, fresh	.06	.04		.04			
Shad, salted	.03			.36			
Spanish mackerel, fresh	.06						
Swordfish, fresh	.19	.08		.06		4.43	.40
Swordfish, salted	.01					.36	
Tautog, fresh				.16			.12
Miscellaneous fish, fresh				.01			
Miscellaneous fish, salted	.02						
Lobsters	.06	.16					.20
Clams (soft)	.02					.22	
Scallops					26.54	5.66	.03
Halibut fins	.10						
Sounds	.02	.08		.04			
Tongues	.15	.04		.08			
Oil, fish	1.83	2.92		1.89			.02
Oil, whale		1.02		6.14		61.11	55.04
Ambergris							1.00
Whalebone				.01			41.20
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The customs districts of Massachusetts having fishing vessels are 10 in number and correspond to some extent with the counties. Table 67 shows in great detail the quantities and values of products taken in each district. Table 68 gives a summary of the vessel fisheries classified by customs districts. A series of average figures is presented in Table 69.

67.—Table showing by species and customs districts the yield of the vessel fisheries of Massachusetts in 1889.

Species.	Newburyport.		Gloucester.		Salem and Beverly.		Marblehead.		Boston.	
	Lbs.	Value.	Lbs.	Value.	Lbs.	Value.	Lbs.	Value.	Lbs.	Value.
Alewives, salted			6,600	$66						
Butter-fish, fresh			6,000	180						
Cod, fresh	144,000	$3,280	7,890,608	178,948	402,993	$8,849	1,129,600	$24,882	4,077,470	$103,978
Cod, salted	6,000	175	44,682,140	1,178,811	1,520,013	38,411	235,000	7,160	1,695,370	39,295
Cunners, fresh									80,000	1,120
Cusk, fresh			261,622	2,971			1,500	16	75,456	756
Cusk, salted			399,405	6,853						
Grouper, fresh									16,868	269
Haddock, fresh	71,000	1,460	16,459,375	304,361	53,000	935	818,500	16,190	10,304,670	157,959
Haddock, salted			605,875	8,643	78,505	820				
Hake, fresh			1,683,810	18,977	4,273	34	182,000	1,855	1,678,523	16,787
Hake, salted			838,948	11,955	16,250	287				
Halibut, fresh			8,242,125	553,864	1,450	102	473	47	190,956	18,776
Halibut, salted			972,237	48,807	2,693	125				
Herring, fresh			197,000	1,790			14,200	161	60,750	377
Herring, salted			650,200	9,303	49,600	612			245,000	3,369

64.—Table showing by counties and species the yield of the vessel fisheries of Massachusetts in 1889—Cont'd.

Species.	Nantucket.		Dukes.		Bristol.		Total for State.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Swordfish, salted			2,400	$84			7,200	$334
Tautog, fresh					18,972	$955	33,972	2,055
Miscellaneous fish, fresh							2,200	44
Miscellaneous fish, salted							54,200	696
Lobsters					29,225	1,535	80,225	3,836
Clams (soft)			400	50			6,800	664
Scallops	7,000	$1,400	7,175	1,305	700	200	14,875	2,905
Halibut fins							62,000	2,754
Sounds							43,933	1,316
Tongues					762	15	251,383	5,026
Oil, fish					4,149	149	2,160,309	77,768
Oil, whale			161,025	14,084	5,457,480	427,560	6,171,518	488,524
Ambergris					37	7,750	37	7,750
Whalebone					97,068	320,031	98,268	320,115
Total	70,000	5,275	334,467	23,048	6,083,126	776,805	148,047,973	4,778,185

Certain averages which throw considerable light on the vessel fisheries of the various counties are given in the following table. The greatest average tonnage is found in Bristol County, in which the whaling vessels constitute a prominent part of the fishing fleet; in Nantucket County, where the shore fishery with lines and nets is the principal branch, the vessels have the least average tonnage; the extremes, as represented by these two counties, are 166.64 and 6.85 tons, respectively. The average value per ton is, singularly enough, greatest in Nantucket County and least in Bristol County. Among the important fishing counties, the average value per ton is greatest in Essex County. The average value of vessels is naturally greatest in Bristol County, in which the vessels are largest, after which comes Essex County. The same statement applies to the average value of apparatus and outfit and the average number of crew. The average value of catch per man is highest in Plymouth County and lowest in Nantucket County. After Plymouth come Suffolk, Essex, and Bristol. In the average stock per vessel Bristol County takes considerable precedence over any other, with $9,710; then come Essex with $6,465 and Suffolk with $6,266. For each ton employed Plymouth County in 1889 took products to the value of $136, Suffolk County $112, and Essex County $101. For each $100 invested in the vessel fisheries the last-named county also took products worth $101, while Plymouth County is credited with $194 and Suffolk County with $117.

65.—Table showing by counties certain average figures for the vessels employed in the fisheries of Massachusetts in 1889.

Counties.	Net tonnage.	Value per ton.	Value per vessel.	Value of apparatus and outfit.	No. of men to vessel.	Value of catch per man.	Value of catch per vessel.	Value of catch per each ton employed.	Value of catch per each $100 invested in fishing vessels.
Essex	64.21	$58	$3,742	$2,689	13	$499	$6,465	$101	$101
Suffolk	55.73	55	3,058	2,305	12	529	6,266	112	117
Plymouth	27.93	43	1,200	763	7	583	3,793	136	194
Barnstable	62.69	44	2,778	2,003	12	302	3,693	59	77
Nantucket	6.85	64	438	58	2	165	330	48	67
Dukes	32.14	39	1,245	1,016	6	184	1,152	36	51
Bristol	166.64	47	7,882	6,122	22	435	9,710	58	89

The comparative importance of each of the principal fishery products in the various counties is shown in the next table. The figures represent the percentage of the value of each species to the total yield in each county.

68.—Summary by customs districts of the vessel fisheries of Massachusetts in 1889.

Customs districts.	No. of vessels fishing.	Net tonnage.	Value of vessels.	Value of outfit, provisions, gear, fuel, etc.	No. and nationality of fishermen.				Value of catch.
					Americans.	British provincials.	Others.	Total.	
Newburyport	3	89.18	$4,600	$3,100	26	1	.....	27	$7,850
Gloucester	403	26,898.79	1,573,025	1,118,258	4,851	275	228	5,354	2,688,149
Salem and Beverly	13	620.56	34,800	20,587	50	12	69	131	54,659
Marblehead	23	772.01	41,375	46,705	206	10	1	217	106,943
Boston	66	3,678.29	201,820	152,137	573	66	143	782	413,576
Plymouth	2	55.85	2,400	1,525	13	.....	.....	13	7,585
Barnstable	188	11,786.22	522,250	376,515	1,327	497	471	2,295	694,295
Nantucket	16	109.65	7,000	920	32	.....	.....	32	5,275
Edgartown	20	642.78	24,900	20,310	94	16	15	125	23,048
New Bedford	80	13,330.85	630,575	489,775	739	280	765	1,784	776,805
Total	814	57,984.18	3,042,745	2,229,832	7,911	1,157	1,692	10,760	4,778,185

Customs districts.	No. of vessels transporting.	Net tonnage.	Value of vessels.	Value of outfit, provisions, fuel, etc.	No. and nationality of crew.				Value of products transported.
					Americans.	British provincials.	Others.	Total.	
Newburyport	.....	.....	.....	.....	.....	.....	.....	.....	.....
Gloucester	4	322.12	$14,800	$1,000	22	.....	.....	22	$25,113
Salem and Beverly	.....	.....	.....	.....	.....	.....	.....	.....	.....
Marblehead	.....	.....	.....	.....	.....	.....	.....	.....	.....
Boston	2	113.92	4,500	600	10	.....	.....	10	10,300
Plymouth	.....	.....	.....	.....	.....	.....	.....	.....	.....
Barnstable	10	479.40	21,500	2,075	42	.....	.....	42	22,700
Nantucket	.....	.....	.....	.....	.....	.....	.....	.....	.....
Edgartown	2	21.07	2,400	250	4	.....	.....	4	2,390
New Bedford	4	338.61	12,400	3,500	13	.....	.....	13	102,902
Total	22	1,275.12	55,600	7,425	91	.....	.....	91	163,405

69.—Table showing by customs districts the average tonnage, value, crew, and stock of vessels employed in the fisheries of Massachusetts in 1889.

Customs districts.	Average tonnage.		Average value.		Average value of outfit and apparatus.		Average number of crew.		Average gross stock.	
	Fishing.	Transporting.	Fishing.	Transporting.	Fishing.	Transporting.	Fishing.	Transporting.	Fishing.	Transporting.*
Newburyport	29.73	.....	$1,533	.....	$1,033	.....	9	.....	$2,617	.....
Gloucester	67.24	80.53	3,903	$3,700	2,775	$250	13	6	6,670	$6,278
Salem and Beverly	47.74	.....	2,677	.....	1,584	.....	10	.....	4,205	.....
Marblehead	33.57	.....	1,799	.....	2,031	.....	9	.....	7,650	.....
Boston	55.73	56.96	3,058	2,250	2,305	300	12	5	6,266	5,150
Plymouth	27.93	.....	1,200	.....	763	.....	7	.....	3,793	.....
Barnstable	62.69	47.94	2,778	2,150	2,003	208	13	4	3,693	2,270
Nantucket	6.85	.....	438	.....	58	.....	2	.....	330	.....
Edgartown	32.14	10.54	1,245	1,200	1,016	125	6	2	1,152	1,195
New Bedford	166.64	84.65	7,870	3,100	6,122	875	22	3	9,710	25,726

* The value of products transported.

The effectiveness and importance of the different means of capture employed in the vessel fisheries of Massachusetts are indicated in the following tabulation. Although hand lines and trawl lines are the simplest and most primitive forms of apparatus, their importance greatly surpasses all other kinds combined, taking, in 1889, 130,953,508 pounds of fish, valued at $3,424,720, while the total yield by all devices was 139,158,625 pounds, worth $3,867,527. The catch in seines amounted to 6,132,816 pounds, valued at $389,154; in nets, 1,832,677 pounds, with a value of $43,112; with harpoons, 239,624 pounds, worth $10,541. The crustaceans and mollusks secured in the vessel fisheries and the products of the whale fishery are not included in the table.

70.—Table showing by apparatus and species the yield of the vessel fisheries of Massachusetts in 1889, exclusive of the molluscan, crustacean, and mammalian fisheries.

Apparatus and species.	Pounds.	Value.	Apparatus and species.	Pounds.	Value.
Lines:			Seines—continued.		
Bluefish, fresh	23,827	$1,876	Menhaden, salted	167,200	$2,872
Cod, fresh	19,180,605	472,173	Shad, fresh	67,200	2,036
Cod, salted	54,698,109	1,487,218	Shad, salted	120,800	3,302
Cusk, fresh	431,778	4,932	Spanish mackerel, fresh	20,000	1,600
Cusk, salted	399,405	6,853	Miscellaneous fish, fresh	2,200	44
Flounders, fresh	3,254	65	Miscellaneous fish, salted	54,200	696
Grouper, fresh	16,868	269			
Haddock, fresh	33,832,526	580,723	Total	6,132,816	389,154
Haddock, salted	697,380	9,593			
Hake, fresh	4,875,506	51,445	Gill nets:		
Hake, salted	855,198	12,242	Alewives, salted	6,600	66
Halibut, fresh	8,913,260	611,640	Bluefish, fresh	51,127	3,235
Halibut, salted	974,930	48,932	Butter-fish, fresh	6,000	180
Mackerel, fresh	87,375	7,745	Cod, fresh	232,600	3,588
Mackerel, salted	762,700	64,844	Cunners, fresh *	80,000	1,120
Pollock, fresh	2,937,438	30,278	Herring, fresh	273,390	2,334
Pollock, salted	1,967,421	23,448	Herring, salted	956,800	13,434
Red snapper, fresh	211,154	6,057	Mackerel, fresh	47,960	4,979
Scup, fresh	27,733	829	Mackerel, salted	178,200	14,176
Sea bass, fresh	23,067	1,503			
Tautog, fresh	33,972	2,055	Total	1,832,677	43,112
Total	130,953,508	3,424,720	Harpoons:		
			Swordfish, fresh	232,424	10,207
Seines:			Swordfish, salted	7,200	334
Flounders, fresh	7,600	152			
Mackerel, fresh	856,816	77,640	Total	239,624	10,541
Mackerel, salted	3,207,200	292,133			
Menhaden, fresh	1,629,600	8,679	Grand total	139,158,625	3,867,527

* Taken with snap nets.

Table 71 shows the number of vessels engaged in each fishery, with their tonnage, value, and crew, from which it will be seen that more vessels are employed in the mackerel fishery than in any other, although the whale fleet has the greatest tonnage, the cod vessels fishing on the eastern banks the greatest value, and the market vessels the largest number of fishermen. Only 2 vessels were engaged in the cod fishery in the Gulf of St. Lawrence and 5 in the Iceland halibut fishery.

71.—Table showing the number of vessels engaged in each fishery in Massachusetts in 1889, together with their tonnage, value, and number of crew.

Fisheries.	No. of vessels engaged.	Net tonnage.	Value of vessels.	Number and nationality of fishermen.			
				Americans.	British provincials.	Others.	Total.
Cod, on banks east of 65° west longitude	192	16,420.28	$870,322	2,131	428	296	2,855
Cod, on banks west of 65° west longitude	112	7,160.36	387,904	1,275	24	115	1,414
Cod, Gulf of St. Lawrence	2	122.05	2,800	15	11	.....	26
Halibut, on banks east of 65° west longitude	41	3,464.86	223,134	559	34	9	602
Halibut, on banks west of 65° west longitude	7	577.70	42,000	80	4	40	124
Halibut, Iceland	5	424.28	21,700	52	24	2	78
Mackerel, New England shore	256	9,917.37	501,538	2,023	227	80	2,330
Mackerel, Nova Scotia shore	2	136.90	8,000	26	.....	6	32
Mackerel, Gulf of St. Lawrence	39	3,264.55	191,242	564	25	25	614
Whale	68	14,303.55	663,400	819	323	776	1,918
Market	201	13,440.18	827,175	2,264	147	466	2,887
Shore	180	3,407.53	172,775	907	50	42	999
Herring	34	742.07	35,550	156	12	6	174
Swordfish	30	440.53	28,050	115	18	6	139
Menhaden	1	26.97	6,000	9	.....	4	13
Lobster	10	151.75	9,000	28	6	1	35
Scallop and clam	12	75.25	4,975	25	.....	.....	25

Table 72 shows a very close resemblance between the two most important fisheries, the bank cod and the market; the aggregate catch in each is practically the same, although the product of the former is somewhat more valuable. The whale fishery ranks third in point of value, and leads by a considerable amount the halibut fishery, which in turn excels the mackerel. The sixth position is held by the shore fishery, which is far in advance of all other branches not mentioned above, none of which have products worth over $16,000.

72.—Table showing by fisheries and species the yield of the vessel fisheries of Massachusetts in 1889.

Fisheries and species.	Pounds.	Value.
Bank cod:		
Cod, fresh	122,795	$2,451
Cod, salted	52,775,905	1,436,502
Cusk, salted	295,626	4,881
Haddock, fresh	6,857	139
Haddock, salted	641,099	8,948
Hake, salted	629,979	8,695
Halibut, fresh	576,626	43,642
Halibut, salted	189,999	10,205
Pollock, fresh	100,219	892
Pollock, salted	1,353,890	15,486
Halibut fins, salted	20,600	926
Total	56,713,595	1,532,767
Market:		
Cod, fresh	16,294,593	409,527
Cod, salted	169,690	4,109
Cusk, fresh	362,878	4,049
Cusk, salted	10,000	200
Grouper, fresh	16,868	269
Haddock, fresh	32,226,899	552,902
Haddock, salted	13,000	130
Hake, fresh	4,268,939	45,384
Hake, salted	12,000	132
Halibut, fresh	835,912	71,511
Pollock, fresh	2,325,369	23,382
Pollock, salted	10,000	150
Red snapper, fresh	211,156	6,057
Spanish mackerel	20,000	1,600
Swordfish, fresh	6,225	297
Total	56,783,529	1,119,699
Mackerel:		
Alewives, salted	6,600	66
Herring, fresh	8,200	82
Herring, salted	46,800	720
Mackerel, fresh	992,151	90,364
Mackerel, salted	4,148,100	371,153
Menhaden, fresh	329,600	2,129
Menhaden, salted	167,200	2,872
Shad, fresh	67,200	2,036
Shad, salted	120,800	3,302
Swordfish, fresh	6,150	235
Swordfish, salted	1,800	100
Miscellaneous fish, salted	54,200	696
Total	5,948,801	473,755
Shore:		
Bluefish, fresh	74,954	5,111
Butter-fish, fresh	6,000	180
Cod, fresh	2,944,331	62,553
Cod, salted	1,615,504	43,138
Cunners, fresh	80,000	1,120
Cusk, fresh	56,900	696
Cusk, salted	89,864	1,703
Flounders, fresh	10,854	217
Haddock, fresh	1,589,770	27,522
Haddock, salted	41,281	475
Hake, fresh	596,567	5,961
Hake, salted	194,274	3,132
Halibut, fresh	100,373	6,434
Shore—continued.		
Herring, fresh	1,440	$6
Menhaden, fresh	80,000	450
Pollock, fresh	511,850	6,004
Pollock, salted	601,531	7,782
Scup, fresh	27,733	829
Sea bass, fresh	23,067	1,503
Swordfish, fresh	5,891	273
Tautog, fresh	33,972	2,055
Miscellaneous fish, fresh	2,200	44
Total	8,688,356	177,188
Halibut:		
Cod, fresh	51,486	1,230
Cod, salted	137,010	3,469
Cusk, fresh	12,000	187
Cusk, salted	3,915	69
Haddock, fresh	9,000	160
Haddock, salted	2,000	40
Hake, fresh	10,000	100
Hake, salted	18,945	283
Halibut, fresh	7,400,349	490,053
Halibut, salted	784,931	38,727
Pollock, salted	2,000	30
Halibut fins, salted	41,400	1,828
Total	8,473,036	536,176
Herring:		
Herring, fresh	263,750	2,246
Herring, salted	910,000	12,714
Menhaden, fresh	20,000	100
Total	1,193,750	15,060
Swordfish:		
Swordfish, fresh	214,158	9,402
Swordfish, salted	5,400	234
Total	219,558	9,636
Menhaden:		
Menhaden, fresh	1,200,000	6,000
Molluscan:		
Clams (soft)	6,800	664
Scallops	14,875	2,905
Total	21,675	3,569
Crustacean:		
Lobsters	80,225	3,836
Whale:		
Whale oil	6,171,518	488,524
Whalebone	98,268	320,115
Ambergris	37	7,750
Total	6,269,823	816,389
Grand total	145,592,348	4,694,075

The catch of mackerel, bank cod, and bank halibut is classified by fishing-grounds in the following table. The yield of mackerel by each kind of apparatus is also specified. The figures are interesting as showing the importance of some of the principal grounds resorted to by American fishing vessels.

73.—Table showing by fishing-grounds the catch of the mackerel (by apparatus), the bank cod, the Grand and Western bank fresh halibut, and the Iceland halibut fleets of Massachusetts in 1889.

Species.	New England shore.		Nova Scotia shore.		Gulf of St. Lawrence.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Mackerel, caught with seines, fresh	856,816	$77,640				
Mackerel, caught with seines, salted	2,206,400	197,240	8,200	$603	992,600	$94,290
Mackerel, caught with nets, fresh	47,960	4,979				
Mackerel, caught with nets, salted	178,200	14,176				
Mackerel, caught with lines, fresh	87,375	7,745				
Mackerel, caught with lines, salted	752,700	63,782			10,000	1,062
Cod, salted					239,500	9,608
Total	4,129,451	365,562	8,200	603	1,242,100	104,960

Species.	East of 65° W. longitude.		West of 65° W. longitude.		Iceland.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Mackerel, caught with seines, fresh							856,816	$77,640
Mackerel, caught with seines, salted							3,207,200	292,133
Mackerel, caught with nets, fresh							47,960	4,979
Mackerel, caught with nets, salted							178,200	14,176
Mackerel, caught with lines, fresh							87,375	7,745
Mackerel, caught with lines, salted							762,700	64,844
Cod, salted	35,734,380	$981,910	16,939,035	$448,453			52,912,915	1,439,971
Halibut, fresh	7,166,861	469,179	810,108	64,494			7,976,969	533,673
Halibut, salted	176,571	8,887			746,883	$37,092	923,454	45,979
Total	43,077,812	1,459,976	17,749,143	512,947	746,883	37,092	66,953,589	2,481,140

THE SHORE FISHERIES.

The shore fisheries of Massachusetts yield a smaller percentage of the value of its total fishery products than in any other New England State; nevertheless, the State is second only to Maine in this respect, surpassing in importance the combined value of the shore fisheries of the three remaining coast States. The special features which give prominence in this branch are the pound net, lobster, and molluscan fisheries.

The extent to which the citizens of each of the eight coastal counties of Massachusetts engaged in the shore and boat fisheries in 1889 is set forth in the following series of tables, the first of which relates to persons engaged, the second to the boats and apparatus used, and the third to the quantity and value of products taken.

From the first table it is seen that Barnstable County occupies a very prominent position in the shore fisheries, for, of the 3,748 shore fishermen in the State, no less than 1,840 are credited to that county. Plymouth, the county with the least important vessel fisheries, ranks second in number of shore fishermen, having 575, while Essex County, with 5,751 vessel fishermen, ranks third, with only 454 shore fishermen.

64.—Table showing by counties and species the yield of the vessel fisheries of Massachusetts in 1889.

Species.	Essex.		Suffolk.		Plymouth.		Barnstable.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives, salted	6,600	$66						
Bluefish, fresh							24,927	$1,521
Butter-fish, fresh	6,000	180						
Cod, fresh	9,567,201	215,959	4,077,470	$103,978	96,500	$1,875	5,594,012	151,441
Cod, salted	46,443,153	1,224,557	1,695,370	39,295			6,376,986	217,611
Cunners, fresh			80,000	1,120				
Cusk, fresh	263,122	2,987	75,456	756			93,200	1,189
Cusk, salted	399,405	6,853						
Flounders, fresh							7,600	152
Groupers, fresh			16,868	269				
Haddock, fresh	17,401,875	322,946	10,304,670	157,956	94,500	1,580	6,028,281	98,174
Haddock, salted	684,380	9,463					13,000	130
Hake, fresh	1,870,083	20,866	1,678,523	16,787	1,900	20	1,325,000	13,772
Hake, salted	855,198	12,242						
Halibut, fresh	8,244,048	554,013	190,956	18,776			478,256	38,851
Halibut, salted	974,930	48,932						
Herring, fresh	211,200	1,951	60,750	377			1,440	6
Herring, salted	699,800	9,915	245,000	3,369			12,000	150
Mackerel, fresh	584,040	48,976	252,976	27,458	41,100	4,110	98,704	8,626
Mackerel, salted	2,786,200	256,490	222,000	21,004			1,015,600	84,246
Menhaden, fresh	269,000	1,385	68,600	344			1,200,000	6,000
Menhaden, salted	167,200	2,872						
Pollock, fresh	2,325,004	23,278	94,334	1,660			518,100	5,340
Pollock, salted	1,516,066	17,401	255	3			451,100	6,044
Red snapper, fresh	120,000	3,600	91,156	2,457				
Shad, fresh	41,400	1,616	6,000	180			19,800	240
Shad, salted	26,000	780					94,800	2,522
Spanish mackerel, fresh	20,000	1,600						
Swordfish, fresh	108,958	5,305	9,100	344			12,700	419
Swordfish, salted	4,800	250						
Tautog, fresh							15,000	1,100
Miscellaneous fish, fresh							2,200	44
Miscellaneous fish, salted	54,200	696						
Lobsters	37,500	1,635	13,500	666				
Clams (soft)	6,400	614						
Halibut fins	62,000	2,754						
Sounds	23,911	716	11,189	335			8,833	265
Tongues	213,929	4,278	7,706	154			28,986	579
Oil, fish	1,456,287	52,425	335,019	12,060			364,854	13,134
Oil, whale			48,750	4,225			504,263	42,655
Whalebone							1,200	84
Total	97,449,890	2,857,601	19,585,648	413,576	234,000	7,585	24,290,842	694,295

Species.	Nantucket.		Dukes.		Bristol.		Total for State.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives, salted							6,600	$66
Bluefish, fresh	20,000	$1,600	28,427	$1,862	1,600	$128	74,954	5,111
Butter-fish, fresh							6,000	180
Cod, fresh	15,000	375	10,722	362	52,300	1,771	19,413,205	475,761
Cod, salted	15,000	600			167,600	5,155	54,698,109	1,487,218
Cunners, fresh							80,000	1,120
Cusk, fresh							431,778	4,932
Cusk, salted							399,405	6,853
Flounders, fresh			3,254	65			10,854	217
Groupers, fresh							16,868	269
Haddock, fresh			3,200	64			33,832,526	580,723
Haddock, salted							697,380	9,593
Hake, fresh							4,875,506	51,445
Hake, salted							855,198	12,242
Halibut, fresh							8,913,260	611,640
Halibut, salted							974,930	48,932
Herring, fresh							273,390	2,334
Herring, salted							956,800	13,434
Mackerel, fresh	8,000	800	6,331	294	1,000	100	992,151	90,364
Mackerel, salted	5,000	500	14,100	1,122	105,200	7,791	4,148,100	371,153
Menhaden, fresh			32,000	800	60,000	150	1,629,600	8,679
Menhaden, salted							167,200	2,872
Pollock, fresh							2,937,438	30,278
Pollock, salted							1,967,421	23,448
Red snapper, fresh							211,156	6,057
Sea bass, fresh			23,067	1,503			23,067	1,503
Scup, fresh			16,900	431	10,833	398	27,733	829
Shad, fresh							67,200	2,036
Shad, salted							120,800	3,302
Spanish mackerel, fresh							20,000	1,600
Swordfish, fresh			25,466	1,022	76,206	3,117	232,424	10,207

64.—Table showing by counties and species the yield of the vessel fisheries of Massachusetts in 1889—Cont'd.

Species.	Nantucket.		Dukes.		Bristol.		Total for State.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Swordfish, salted			2,400	$84			7,200	$334
Tautog, fresh					18,972	$955	33,972	2,055
Miscellaneous fish, fresh							2,200	44
Miscellaneous fish, salted							54,200	696
Lobsters					29,225	1,535	80,225	3,836
Clams (soft)			400	50			6,800	664
Scallops	7,000	$1,400	7,175	1,305	700	200	14,875	2,905
Halibut fins							62,000	2,754
Sounds							43,933	1,316
Tongues					762	15	251,383	5,026
Oil, fish					4,149	149	2,160,309	77,768
Oil, whale			161,025	14,084	5,457,480	427,560	6,171,518	488,524
Ambergris					37	7,750	37	7,750
Whalebone					97,068	320,031	98,268	320,115
Total	70,000	5,275	334,467	23,048	6,083,126	776,805	148,047,973	4,778,185

Certain averages which throw considerable light on the vessel fisheries of the various counties are given in the following table. The greatest average tonnage is found in Bristol County, in which the whaling vessels constitute a prominent part of the fishing fleet; in Nantucket County, where the shore fishery with lines and nets is the principal branch, the vessels have the least average tonnage; the extremes, as represented by these two counties, are 166.64 and 6.85 tons, respectively. The average value per ton is, singularly enough, greatest in Nantucket County and least in Bristol County. Among the important fishing counties, the average value per ton is greatest in Essex County. The average value of vessels is naturally greatest in Bristol County, in which the vessels are largest, after which comes Essex County. The same statement applies to the average value of apparatus and outfit and the average number of crew. The average value of catch per man is highest in Plymouth County and lowest in Nantucket County. After Plymouth come Suffolk, Essex, and Bristol. In the average stock per vessel Bristol County takes considerable precedence over any other, with $9,710; then come Essex with $6,465 and Suffolk with $6,266. For each ton employed Plymouth County in 1889 took products to the value of $136, Suffolk County $112, and Essex County $101. For each $100 invested in the vessel fisheries the last-named county also took products worth $101, while Plymouth County is credited with $194 and Suffolk County with $117.

65.—Table showing by counties certain average figures for the vessels employed in the fisheries of Massachusetts in 1889.

Counties.	Net tonnage.	Value per ton.	Value per vessel.	Value of apparatus and outfit.	No. of men to vessel.	Value of catch per man.	Value of catch per vessel.	Value of catch per each ton employed.	Value of catch per each $100 invested in fishing vessels.
Essex	64.21	$58	$3,742	$2,689	13	$499	$6,465	$101	$101
Suffolk	55.73	55	3,058	2,305	12	529	6,266	112	117
Plymouth	27.93	43	1,200	763	7	583	3,793	136	194
Barnstable	62.69	44	2,778	2,003	12	302	3,693	59	77
Nantucket	6.85	64	438	58	2	165	330	48	67
Dukes	32.14	39	1,245	1,016	6	184	1,152	36	51
Bristol	166.64	47	7,882	6,122	22	435	9,710	58	69

The comparative importance of each of the principal fishery products in the various counties is shown in the next table. The figures represent the percentage of the value of each species to the total yield in each county.

66.—Table showing by counties the percentage of value of each species or product taken in the vessel fisheries of Massachusetts in 1889.

Species.	Essex.	Suffolk.	Plymouth.	Barnstable.	Nantucket.	Dukes.	Bristol.
Alewives, salted	[.002]						
Bluefish, fresh				.22	30.33	8.08	.02
Butter-fish, fresh	.01						
Cod, fresh	7.56	25.14	24.72	21.81	7.11	1.57	.23
Cod, salted	42.85	9.50		31.34	11.37		.66
Cunners, fresh		.27					
Cusk, fresh	.10	.18		.17			
Cusk, salted	.24						
Flounders, fresh				.02		.28	
Groupers, fresh		.07					
Haddock, fresh	11.30	38.19	20.83	14.14		.28	
Haddock, salted	.33			.02			
Hake, fresh	.73	4.06	.26	1.98			
Hake, salted	.43						
Halibut, fresh	19.39	4.54		5.60			
Halibut, salted	1.71						
Herring, fresh	.07	.09					
Herring, salted	.35	.82		.02			
Mackerel, fresh	1.71	6.64	54.19	1.24	15.17	1.28	.01
Mackerel, salted	8.97	5.08		12.14	9.48	4.87	1.00
Menhaden, fresh	.05	.08		.87		3.47	.02
Menhaden, salted	.10						
Pollock, fresh	.81	.40		.77			
Pollock, salted	.61			.87			
Red snapper, fresh	.13	.60					
Sea bass, fresh						6.52	
Scup, fresh						1.87	.05
Shad, fresh	.06	.04		.04			
Shad, salted	.03			.36			
Spanish mackerel, fresh	.06						
Swordfish, fresh	.19	.08		.06		4.43	.40
Swordfish, salted	.01					.36	
Tautog, fresh				.16			.12
Miscellaneous fish, fresh				.01			
Miscellaneous fish, salted	.02						
Lobsters	.06	.16					.20
Clams (soft)	.02					.22	
Scallops					26.54	5.66	.03
Halibut fins	.10						
Sounds	.02	.08		.04			
Tongues	.15	.04		.08			
Oil, fish	1.83	2.92		1.89			.02
Oil, whale		1.02		6.14		61.11	55.04
Ambergris							1.00
Whalebone				.01			41.20
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The customs districts of Massachusetts having fishing vessels are 10 in number and correspond to some extent with the counties. Table 67 shows in great detail the quantities and values of products taken in each district. Table 68 gives a summary of the vessel fisheries classified by customs districts. A series of average figures is presented in Table 69.

67.—Table showing by species and customs districts the yield of the vessel fisheries of Massachusetts in 1889.

Species.	Newburyport.		Gloucester.		Salem and Beverly.		Marblehead.		Boston.	
	Lbs.	Value.	Lbs.	Value.	Lbs.	Value.	Lbs.	Value.	Lbs.	Value.
Alewives, salted			6,600	$66						
Butter-fish, fresh			6,000	180						
Cod, fresh	144,000	$3,280	7,890,608	178,948	402,993	$8,849	1,129,600	$24,882	4,077,470	$103,978
Cod, salted	6,000	175	44,682,140	1,178,811	1,520,013	38,411	235,000	7,160	1,695,370	39,295
Cunners, fresh									80,000	1,120
Cusk, fresh			261,622	2,971			1,500	16	75,456	756
Cusk, salted			399,405	6,853						
Grouper, fresh									16,868	269
Haddock, fresh	71,000	1,460	16,459,375	304,361	53,000	935	818,500	16,190	10,304,670	157,959
Haddock, salted			605,875	8,643	78,505	820				
Hake, fresh			1,683,810	18,977	4,273	34	182,000	1,855	1,678,523	16,787
Hake, salted			838,948	11,955	16,250	287				
Halibut, fresh			8,242,125	553,864	1,450	102	473	47	190,956	18,776
Halibut, salted			972,237	48,807	2,693	125				
Herring, fresh			197,000	1,790			14,200	161	60,750	377
Herring, salted			650,200	9,303	49,600	612			245,000	3,369

67.—Table showing by species and customs districts the yield of the vessel fisheries of Massachusetts in 1889—Continued.

Species.	Newburyport.		Gloucester.		Salem and Beverly.		Marblehead.		Boston.	
	Lbs.	Value.	Lbs.	Value.	Lbs.	Value.	Lbs.	Value.	Lbs.	Value.
Mackerel, fresh	9,400	$910	54,600	$5,400			520,040	$666	252,976	$27,458
Mackerel, salted	33,600	2,025	2,724,000	251,761	11,200	$1,101	17,400	42,603	222,000	21,004
Menhaden, fresh			110,600	1,007			158,400	1,378	68,600	344
Menhaden, salted			167,200	2,872						
Pollock, fresh			2,027,131	19,582	10,273	154	287,600	3,542	94,334	1,660
Pollock, salted			1,503,066	17,271	13,000	130			255	3
Red snapper, fresh							120,000	3,600	91,156	2,457
Shad, fresh							41,400	1,616	6,000	180
Shad, salted							26,000	780		
Spanish mack'l, fresh			20,000	1,600						
Swordfish, fresh			105,558	5,135			3,400	170	9,100	344
Swordfish, salted			4,800	250						
Miscellaneous, salted			54,200	696						
Lobsters			1,500	60	36,000	1,575			13,500	666
Clams (soft)							6,400	614		
Halibut fins			62,000	2,754						
Sounds			22,411	672	287	8	1,213	36	11,189	335
Tongues			205,952	4,119	6,909	138	1,068	21	7,706	154
Oil, fish			1,373,360	49,441	38,302	1,378	44,625	1,606	335,019	12,060
Oil, whale									48,750	4,225
Total	264,000	7,850	91,332,323	2,688,149	2,244,748	54,659	3,608,819	106,943	19,585,648	413,576

Species.	Plymouth.		Barnstable.		Nantucket.		Edgartown.		New Bedford.		Total for State.	
	Lbs.	Value.	Lbs.	Value.	Lbs.	Value.	Lbs.	Value.	Lbs.	Value.	Lbs.	Value.
Alewives, salted											6,600	$66
Bluefish, fresh			24,927	$1,521	20,000	$1,600	28,427	$1,862	1,600	$128	74,954	5,111
Butter-fish, fresh											6,000	180
Cod, fresh	98,500	$1,875	5,594,012	151,441	15,000	375	10,722	362	52,300	1,771	19,413,205	475,761
Cod, salted			6,376,986	217,611	15,000	600			167,600	5,155	54,698,109	1,487,218
Cunners, fresh											80,000	1,120
Cusk, fresh			93,200	1,189							431,778	4,932
Cusk, salted											399,405	6,853
Flounders, fresh			7,600	152			3,254	65			10,854	217
Grouper, fresh											16,808	269
Haddock, fresh	94,500	1,580	6,028,281	98,174			3,200	64			33,832,526	580,723
Haddock, salted			13,000	130							697,380	9,593
Hake, fresh	1,900	20	1,325,000	13,772							4,875,506	51,445
Hake, salted											855,198	12,242
Halibut, fresh			478,256	38,851							8,913,260	611,640
Halibut, salted											974,930	48,932
Herring, fresh			1,440	6							273,390	2,334
Herring, salted			12,000	150							956,800	13,434
Mackerel, fresh	41,100	4,110	98,704	8,626	8,000	800	6,331	294	1,000	100	992,151	90,364
Mackerel, salted			1,015,600	84,246	5,000	500	14,100	1,122	105,200	7,791	4,148,100	371,153
Menhaden, fresh			1,200,000	6,000			32,000	800	60,000	150	1,629,600	8,679
Menhaden, salted											167,200	2,872
Pollock, fresh			518,100	5,340							2,937,438	30,278
Pollock, salted			451,100	6,044							1,967,421	23,448
Redsnapper, fresh											211,156	6,057
Sea bass, fresh							23,067	1,503			23,067	1,503
Scup, fresh							16,900	431	10,833	398	27,733	829
Shad, fresh			19,800	240							67,200	2,036
Shad, salted			94,800	2,522							120,800	3,302
Spanish mackerel, fresh											20,000	1,600
Swordfish, fresh			12,700	419			25,466	1,022	76,200	3,117	232,424	10,207
Swordfish, salted							2,400	84			7,200	334
Tautog, fresh			15,000	1,100					18,972	955	33,972	2,055
Miscellaneous fish, fresh			2,200	44							2,200	44
Miscellaneous fish, salted											54,200	696
Lobsters									29,225	1,535	80,225	3,836
Clams (soft)							400	50			6,800	664
Scallops					7,000	1,400	7,175	1,305	700	200	14,875	2,905
Halibut fins											62,000	2,754
Sounds			8,833	265							43,933	1,316
Tongues			28,986	579					762	15	251,383	5,026
Oil, fish			364,854	13,134					4,149	149	2,160,309	77,768
Oil, whale			504,263	42,655			161,025	14,084	5,457,480	427,560	6,171,518	488,524
Ambergris									37	7,750	37	7,750
Whalebone			1,200	84					97,068	320,031	98,268	320,115
Total	234,000	7,585	24,290,842	694,295	70,000	5,275	334,467	23,048	6,083,126	776,805	148,047,973	4,778,185

Barnstable County is equally prominent in the quantity and value of boats and apparatus used in the shore fisheries. The total investment in the State was $567,220, of which $295,074 was the value of boats and apparatus owned in Barnstable County.* Plymouth County had $90,528 invested, Dukes County $56,632, Essex County $51,391, and Bristol County $44,799; each of the remaining counties had property worth less than $15,000. The 3,494 boats used in the shore fisheries were worth $254,033 and were, naturally, the most prominent single item of expense. Of apparatus, pound nets and trap nets were the most important. The number set in 1889 was 224, valued at $222,583, of which 97, worth $156,332, were owned in Barnstable County. Pots and gill nets are the only remaining forms of apparatus having a high value and deserving special mention; of the former, 27,294 were used, worth $38,697, and of the latter, 3,128, valued at $32,753.

The shore fisheries in 1889 yielded 151,169,696 pounds, for which the fishermen received $1,080,089. More than a third of this quantity, viz, 54,254,926 pounds, and more than two-fifths of the value, viz, $412,604, represented the fisheries of Barnstable County. The next important counties were Essex, 7,342,524 pounds, $174,660; Dukes, 26,194,734 pounds, $135,209; Plymouth, 14,665,573 pounds, $129,423; and Bristol, 38,387,976 pounds, $109,584.

The lobster is the most valuable single species taken in the shore fisheries of the State; 3,273,562 pounds were caught in 1889, the price of which was $144,656. The lobster fishery is the most extensive in Essex, Suffolk, and Plymouth counties, but it is somewhat important in all the other counties except Norfolk.

The soft clam (*Mya arenaria*) is the next important species obtained by the shore fishermen of Massachusetts; a small percentage of the catch is salted for bait, but most of the clams are marketed in a fresh condition. In 1889 the aggregate output of fresh and salt clams was 2,511,430 pounds, equivalent to about 240,151 bushels, for which the fishermen received $137,047. More than half the yield was taken in Essex County.

The catch of fresh and salt mackerel amounted to 1,546,944 pounds, valued at $123,074. By far the largest part of this was taken in Barnstable County. Essex is the only other county having a shore mackerel fishery of any extent. Mackerel is the most valuable fish in the shore fisheries of Massachusetts, and is third in value among fishery products, being surpassed by the two invertebrates already mentioned.

Scup is the next important species, 2,473,432 pounds being secured, returning the fishermen $81,824. The principal catch is made in Dukes and Barnstable counties.

Herring is the most abundant species taken in this fishery; 8,701,188 pounds of fresh and salt fish, valued at $74,994, were landed in 1889. It is extensively utilized for bait. Although the herring is captured in every coast county but Nantucket, the fishery may be said to be confined to Barnstable, Essex, and Suffolk counties.

Algæ, sea weeds, or sea mosses are the next most valuable products of the Massachusetts shore fisheries. No less than 117,993,900 pounds, or 58,997 tons, worth $66,034, were utilized, mostly in Plymouth, Barnstable, Dukes, and Bristol counties. The gathering and preparation of Irish moss is an industry of some consequence, and one which will probably increase.

* A notable innovation of recent years is the employment in Barnstable County of steam pound-net boats, sturdy steam launches about 30 feet long, built expressly for the purpose.

70.—Table showing by apparatus and species the yield of the vessel fisheries of Massachusetts in 1889, exclusive of the molluscan, crustacean, and mammalian fisheries.

Apparatus and species.	Pounds.	Value.	Apparatus and species.	Pounds.	Value.
Lines:			Seines—continued.		
Bluefish, fresh	23,827	$1,876	Menhaden, salted	167,200	$2,872
Cod, fresh	19,180,605	472,173	Shad, fresh	67,200	2,036
Cod, salted	54,698,109	1,487,218	Shad, salted	120,800	3,302
Cusk, fresh	431,778	4,932	Spanish mackerel, fresh	20,000	1,600
Cusk, salted	399,405	6,853	Miscellaneous fish, fresh	2,200	44
Flounders, fresh	3,254	65	Miscellaneous fish, salted	54,200	696
Grouper, fresh	16,868	269			
Haddock, fresh	33,832,526	580,723	Total	6,132,816	389,154
Haddock, salted	697,380	9,593			
Hake, fresh	4,875,506	51,445	Gill nets:		
Hake, salted	855,198	12,242	Alewives, salted	6,600	66
Halibut, fresh	8,913,200	611,640	Bluefish, fresh	51,127	3,235
Halibut, salted	974,930	48,932	Butter-fish, fresh	6,000	180
Mackerel, fresh	87,375	7,745	Cod, fresh	232,600	3,588
Mackerel, salted	762,700	64,844	Cunners, fresh *	80,000	1,120
Pollock, fresh	2,937,438	30,278	Herring, fresh	273,390	2,334
Pollock, salted	1,967,421	23,448	Herring, salted	956,800	13,434
Red snapper, fresh	211,154	6,057	Mackerel, fresh	47,960	4,979
Scup, fresh	27,733	829	Mackerel, salted	178,200	14,176
Sea bass, fresh	23,067	1,503			
Tautog, fresh	33,972	2,055	Total	1,832,677	43,112
Total	130,953,508	3,424,720	Harpoons:		
			Swordfish, fresh	232,424	10,207
Seines:			Swordfish, salted	7,200	334
Flounders, fresh	7,600	152			
Mackerel, fresh	856,816	77,640	Total	239,624	10,541
Mackerel, salted	3,207,200	292,133			
Menhaden, fresh	1,629,600	8,679	Grand total	139,158,625	3,867,527

* Taken with snap nets.

Table 71 shows the number of vessels engaged in each fishery, with their tonnage, value, and crew, from which it will be seen that more vessels are employed in the mackerel fishery than in any other, although the whale fleet has the greatest tonnage, the cod vessels fishing on the eastern banks the greatest value, and the market vessels the largest number of fishermen. Only 2 vessels were engaged in the cod fishery in the Gulf of St. Lawrence and 5 in the Iceland halibut fishery.

71.—Table showing the number of vessels engaged in each fishery in Massachusetts in 1889, together with their tonnage, value, and number of crew.

Fisheries.	No. of vessels engaged.	Net tonnage.	Value of vessels.	Number and nationality of fishermen.			
				Americans.	British provincials.	Others.	Total.
Cod, on banks east of 65° west longitude	192	16,420.28	$870,322	2,131	428	296	2,855
Cod, on banks west of 65° west longitude	112	7,160.36	387,904	1,275	24	115	1,414
Cod, Gulf of St. Lawrence	2	122.05	2,800	15	11	.....	26
Halibut, on banks east of 65° west longitude	41	3,464.86	223,134	559	34	9	602
Halibut, on banks west of 65° west longitude	7	577.70	42,000	80	4	40	124
Halibut, Iceland	5	424.28	21,700	52	24	2	78
Mackerel, New England shore	256	9,917.37	501,538	2,023	227	80	2,330
Mackerel, Nova Scotia shore	2	136.90	8,000	26	.....	6	32
Mackerel, Gulf of St. Lawrence	39	3,264.55	191,242	564	25	25	614
Whale	68	14,303.55	663,400	819	323	776	1,918
Market	201	13,440.18	827,175	2,264	147	466	2,887
Shore	180	3,407.53	172,775	907	50	42	999
Herring	34	742.07	35,550	156	12	6	174
Swordfish	30	440.53	28,050	115	18	6	139
Menhaden	1	26.97	6,000	9	.....	4	13
Lobster	10	151.75	9,000	28	6	1	35
Scallop and clam	12	75.25	4,975	25	.....	.....	25

Table 72 shows a very close resemblance between the two most important fisheries, the bank cod and the market; the aggregate catch in each is practically the same, although the product of the former is somewhat more valuable. The whale fishery ranks third in point of value, and leads by a considerable amount the halibut fishery, which in turn excels the mackerel. The sixth position is held by the shore fishery, which is far in advance of all other branches not mentioned above, none of which have products worth over $16,000.

72.—Table showing by fisheries and species the yield of the vessel fisheries of Massachusetts in 1889.

Fisheries and species.	Pounds.	Value.
Bank cod:		
Cod, fresh	122,795	$2,451
Cod, salted	52,775,905	1,436,502
Cusk, salted	295,626	4,881
Haddock, fresh	6,857	139
Haddock, salted	641,099	8,948
Hake, salted	629,979	8,695
Halibut, fresh	576,626	43,642
Halibut, salted	189,999	10,205
Pollock, fresh	100,219	892
Pollock, salted	1,353,890	15,486
Halibut fins, salted	20,600	926
Total	56,713,595	1,532,767
Market:		
Cod, fresh	16,294,593	409,527
Cod, salted	169,690	4,109
Cusk, fresh	362,878	4,049
Cusk, salted	10,000	200
Grouper, fresh	16,868	269
Haddock, fresh	32,226,899	552,902
Haddock, salted	13,000	130
Hake, fresh	4,268,939	45,384
Hake, salted	12,000	132
Halibut, fresh	835,912	71,511
Pollock, fresh	2,325,369	23,382
Pollock, salted	10,000	150
Red snapper, fresh	211,156	6,057
Spanish mackerel	20,000	1,600
Swordfish, fresh	6,225	297
Total	56,783,529	1,119,699
Mackerel:		
Alewives, salted	6,600	66
Herring, fresh	8,200	82
Herring, salted	48,800	720
Mackerel, fresh	992,151	90,364
Mackerel, salted	4,148,100	371,153
Menhaden, fresh	329,600	2,129
Menhaden, salted	167,200	2,872
Shad, fresh	67,200	2,036
Shad, salted	120,800	3,302
Swordfish, fresh	6,150	235
Swordfish, salted	1,800	100
Miscellaneous fish, salted	54,200	696
Total	5,948,801	473,755
Shore:		
Bluefish, fresh	74,954	5,111
Butter-fish, fresh	6,000	180
Cod, fresh	2,944,331	62,553
Cod, salted	1,615,504	43,138
Cunners, fresh	80,000	1,120
Cusk, fresh	56,900	696
Cusk, salted	89,864	1,703
Flounders, fresh	10,854	217
Haddock, fresh	1,589,770	27,522
Haddock, salted	41,281	475
Hake, fresh	596,567	5,961
Hake, salted	194,274	3,132
Halibut, fresh	100,373	6,434
Shore—continued.		
Herring, fresh	1,440	$6
Menhaden, fresh	80,000	450
Pollock, fresh	511,850	6,004
Pollock, salted	601,531	7,782
Scup, fresh	27,733	829
Sea bass, fresh	23,067	1,503
Swordfish, fresh	5,891	273
Tautog, fresh	33,972	2,055
Miscellaneous fish, fresh	2,200	44
Total	8,688,356	177,188
Halibut:		
Cod, fresh	51,486	1,230
Cod, salted	137,010	3,469
Cusk, fresh	12,000	187
Cusk, salted	3,915	69
Haddock, fresh	9,000	160
Haddock, salted	2,000	40
Hake, fresh	10,000	100
Hake, salted	18,945	283
Halibut, fresh	7,400,349	490,053
Halibut, salted	784,931	38,727
Pollock, salted	2,000	30
Halibut fins, salted	41,400	1,828
Total	8,473,036	536,176
Herring:		
Herring, fresh	263,750	2,246
Herring, salted	910,000	12,714
Menhaden, fresh	20,000	100
Total	1,193,750	15,060
Swordfish:		
Swordfish, fresh	214,158	9,402
Swordfish, salted	5,400	234
Total	219,558	9,636
Menhaden:		
Menhaden, fresh	1,200,000	6,000
Molluscan:		
Clams (soft)	6,800	664
Scallops	14,875	2,905
Total	21,675	3,569
Crustacean:		
Lobsters	80,225	3,836
Whale:		
Whale oil	6,171,518	488,524
Whalebone	98,268	320,115
Ambergris	37	7,750
Total	6,269,823	816,389
Grand total	145,592,348	4,694,075

The catch of mackerel, bank cod, and bank halibut is classified by fishing-grounds in the following table. The yield of mackerel by each kind of apparatus is also specified. The figures are interesting as showing the importance of some of the principal grounds resorted to by American fishing vessels.

73.—Table showing by fishing-grounds the catch of the mackerel (by apparatus), the bank cod, the Grand and Western bank fresh halibut, and the Iceland halibut fleets of Massachusetts in 1889.

Species.	New England shore.		Nova Scotia shore.		Gulf of St. Lawrence.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Mackerel, caught with seines, fresh	856,816	$77,640				
Mackerel, caught with seines, salted	2,206,400	197,240	8,200	$603	992,600	$94,290
Mackerel, caught with nets, fresh	47,960	4,979				
Mackerel, caught with nets, salted	178,200	14,176				
Mackerel, caught with lines, fresh	87,375	7,745				
Mackerel, caught with lines, salted	752,700	63,782			10,000	1,062
Cod, salted					239,500	9,608
Total	4,129,451	365,562	8,200	603	1,242,100	104,960

Species.	East of 65° W. longitude.		West of 65° W. longitude.		Iceland.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Mackerel, caught with seines, fresh							856,816	$77,640
Mackerel, caught with seines, salted							3,207,200	292,133
Mackerel, caught with nets, fresh							47,960	4,979
Mackerel, caught with nets, salted							178,200	14,176
Mackerel, caught with lines, fresh							87,375	7,745
Mackerel, caught with lines, salted							762,700	64,844
Cod, salted	35,734,380	$981,910	16,939,035	$448,453			52,912,915	1,439,971
Halibut, fresh	7,166,861	469,179	810,108	64,494			7,976,969	533,673
Halibut, salted	176,571	8,887			746,883	$37,092	923,454	45,979
Total	43,077,812	1,459,976	17,749,143	512,947	746,883	37,092	66,953,589	2,481,140

THE SHORE FISHERIES.

The shore fisheries of Massachusetts yield a smaller percentage of the value of its total fishery products than in any other New England State; nevertheless, the State is second only to Maine in this respect, surpassing in importance the combined value of the shore fisheries of the three remaining coast States. The special features which give prominence in this branch are the pound net, lobster, and molluscan fisheries.

The extent to which the citizens of each of the eight coastal counties of Massachusetts engaged in the shore and boat fisheries in 1889 is set forth in the following series of tables, the first of which relates to persons engaged, the second to the boats and apparatus used, and the third to the quantity and value of products taken.

From the first table it is seen that Barnstable County occupies a very prominent position in the shore fisheries, for, of the 3,748 shore fishermen in the State, no less than 1,840 are credited to that county. Plymouth, the county with the least important vessel fisheries, ranks second in number of shore fishermen, having 575, while Essex County, with 5,751 vessel fishermen, ranks third, with only 454 shore fishermen.

Barnstable County is equally prominent in the quantity and value of boats and apparatus used in the shore fisheries. The total investment in the State was $567,220, of which $295,074 was the value of boats and apparatus owned in Barnstable County.* Plymouth County had $90,528 invested, Dukes County $56,632, Essex County $51,391, and Bristol County $44,799; each of the remaining counties had property worth less than $15,000. The 3,494 boats used in the shore fisheries were worth $254,033 and were, naturally, the most prominent single item of expense. Of apparatus, pound nets and trap nets were the most important. The number set in 1889 was 224, valued at $222,583, of which 97, worth $156,332, were owned in Barnstable County. Pots and gill nets are the only remaining forms of apparatus having a high value and deserving special mention; of the former, 27,294 were used, worth $38,697, and of the latter, 3,128, valued at $32,753.

The shore fisheries in 1889 yielded 151,169,696 pounds, for which the fishermen received $1,080,089. More than a third of this quantity, viz, 54,254,926 pounds, and more than two-fifths of the value, viz, $412,604, represented the fisheries of Barnstable County. The next important counties were Essex, 7,342,524 pounds, $174,660; Dukes, 26,194,734 pounds, $135,209; Plymouth, 14,665,573 pounds, $129,423; and Bristol, 38,387,976 pounds, $109,584.

The lobster is the most valuable single species taken in the shore fisheries of the State; 3,273,562 pounds were caught in 1889, the price of which was $144,656. The lobster fishery is the most extensive in Essex, Suffolk, and Plymouth counties, but it is somewhat important in all the other counties except Norfolk.

The soft clam (*Mya arenaria*) is the next important species obtained by the shore fishermen of Massachusetts; a small percentage of the catch is salted for bait, but most of the clams are marketed in a fresh condition. In 1889 the aggregate output of fresh and salt clams was 2,511,430 pounds, equivalent to about 240,151 bushels, for which the fishermen received $137,047. More than half the yield was taken in Essex County.

The catch of fresh and salt mackerel amounted to 1,546,944 pounds, valued at $123,074. By far the largest part of this was taken in Barnstable County. Essex is the only other county having a shore mackerel fishery of any extent. Mackerel is the most valuable fish in the shore fisheries of Massachusetts, and is third in value among fishery products, being surpassed by the two invertebrates already mentioned.

Scup is the next important species, 2,473,432 pounds being secured, returning the fishermen $81,824. The principal catch is made in Dukes and Barnstable counties.

Herring is the most abundant species taken in this fishery; 8,701,188 pounds of fresh and salt fish, valued at $74,994, were landed in 1889. It is extensively utilized for bait. Although the herring is captured in every coast county but Nantucket, the fishery may be said to be confined to Barnstable, Essex, and Suffolk counties.

Algæ, sea weeds, or sea mosses are the next most valuable products of the Massachusetts shore fisheries. No less than 117,993,900 pounds, or 58,997 tons, worth $66,034, were utilized, mostly in Plymouth, Barnstable, Dukes, and Bristol counties. The gathering and preparation of Irish moss is an industry of some consequence, and one which will probably increase.

* A notable innovation of recent years is the employment in Barnstable County of steam pound-net boats, sturdy steam launches about 30 feet long, built expressly for the purpose.

The temporary planting of oysters at Boston for a short time during the warm season has not been considered here, since it can not be regarded as a fishery, but it is shown in Table 85.

74.—Table showing by counties the number of men employed in the shore fisheries of Massachusetts in 1889.

Counties.	Number.
Essex	454
Suffolk	160
Norfolk	75
Plymouth	575
Barnstable	1,840
Nantucket	81
Dukes	256
Bristol	307
Total	3,748

75.—Table showing by counties the apparatus employed in the shore fisheries of Massachusetts in 1889.

Designation.	Essex.		Suffolk.		Norfolk.		Plymouth.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Boats	419	$13,915	145	$7,490	51	$3,097	731	$60,166
Pound nets and trap nets	26	20,375					5	3,475
Seines	5	480					7	315
Gill nets	663	6,641	75	750	15	180	362	5,119
Fyke nets	1	10						
Snap nets and dip nets	35	116	87	243			104	285
Trammel nets					2	34	2	36
Trawl and hand lines		1,528				2		179
Pots	4,375	5,896	5,754	5,889	997	1,745	9,288	17,263
Harpoons and spears								30
Dredges, tongs, and rakes		2,430		39				3,660
Total		51,391		14,411		5,058		90,528

Designation.	Barnstable.		Nantucket.		Dukes.		Bristol.		Total.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Boats	1,329	$112,875	97	$3,030	332	$27,216	390	$26,244	3,494	$254,033
Pound nets and trap nets	97	156,332			48	27,208	48	15,193	224	222,583
Seines	28	1,625	17	1,750	1	75			58	4,245
Gill nets	1,641	15,756	289	3,547	65	515	18	245	3,128	32,753
Fyke nets	2	20					12	70	15	100
Snap nets and dip nets	288	347							514	991
Trammel nets									4	70
Trawl and hand lines		1,523		250		77		208		3,770
Pots	3,568	4,131	500	500	1,245	1,541	1,567	1,732	27,294	38,697
Harpoons and spears		224						315		569
Dredges, tongs, and rakes		2,238		250				792		9,409
Total		295,074		9,327		56,632		44,799		567,220

76.—Table showing by counties and species the yield of the shore fisheries of Massachusetts in 1889.

Species.	Essex.		Suffolk.		Norfolk.		Plymouth.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Albacore, fresh							1,200	$15
Alewives, fresh	105,732	$926					266,979	3,400
Alewives, salted							172,750	3,264
Bluefish, fresh	100	10					84,203	7,704
Bonito, fresh	78	2					365	30
Butter-fish, fresh	62,109	1,498			535	$64	10,340	336
Cod, fresh	745,200	16,279					154,723	3,132
Cod, salted	700	16						
Cunners, fresh	74,050	2,539	212,000	$10,600	5,590	280	40,755	2,914
Eels, fresh	17,500	1,280	59,340	4,747			13,860	918
Flounders, fresh	11,254	266					1,947	43
Haddock, fresh	364,900	6,801					80,611	1,349
Hake, fresh	452,800	3,395						
Halibut, fresh							200	14
Herring, fresh	2,356,860	19,056	50,000	750			44,000	120
Herring, salted	265,200	3,217	640,000	6,400	1,700	34	21,000	187
Kingfish, fresh							816	45
Mackerel, fresh	132,792	10,974			650	45	43,300	4,878
Mackerel, salted	4,200	373					11,700	914

76.—Table showing by counties and species the yield of the shore fisheries of Massachusetts in 1889—Cont'd.

Species.	Essex.		Suffolk.		Norfolk.		Plymouth.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Menhaden, fresh	389,200	$3,046					38,606	$140
Menhaden, salted	3,000	72						
Pollock, fresh	144,000	1,503						
Salmon, fresh	15	4						
Scup, fresh							34,806	1,977
Sea bass, fresh	37	5					47,100	2,785
Shad, fresh	548	23					3,527	102
Spanish mackerel, fresh							176	64
Smelt, fresh	4,000	450					1,700	102
Squeteague, fresh							2,390	141
Striped bass, fresh							119	19
Sturgeon, fresh							600	21
Tautog, fresh							48,843	2,759
Whiting, fresh	2,500	40					1,005	10
Miscellaneous fish, fresh	3,336	55						
Refuse fish, fresh	9,000	63					30,000	30
Squid, fresh	2,800	34						
Lobsters, fresh	541,413	31,298	678,150	$36,086			1,262,628	45,694
Clams (soft), fresh	1,238,600	70,860	542,540	25,181			272,000	17,299
Quahogs, fresh							24,288	2,752
Scallops, fresh							23,650	5,169
Oysters							55,272	12,062
Algæ	410,000	575			3,525,490	$7,127	11,870,114	9,034
Total	7,342,524	174,660	2,182,030	83,764	3,533,965	7,550	14,665,573	129,423

Species.	Barnstable.		Nantucket.		Dukes.		Bristol.		Total for State.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Albacore, fresh	73,500	$276							74,700	$291
Alewives, fresh	1,147,580	17,096			28,100	$370	484,300	$7,381	2,032,691	29,173
Alewives, salted	1,072,600	18,952							1,245,350	22,216
Bluefish, fresh	175,199	15,561	20,954	$1,676	17,514	1,633	24,043	2,091	322,013	28,675
Bonito, fresh	27,932	827			163,008	7,180	2,683	118	194,066	8,157
Bonito, salted	1,400	88							1,400	88
Butter-fish, fresh	194,557	5,953			285,300	9,743	203,597	5,334	756,438	22,928
Cod, fresh	659,710	9,889	10,000	250	3,200	158	119,675	2,397	1,692,508	32,105
Cod, salted	371,270	13,123	103,209	2,785	63,000	1,890			538,179	17,814
Cunners, fresh	15,700	1,335							348,095	17,668
Eels, fresh	235,575	13,008	20,000	1,000	45,000	1,500	33,433	1,842	424,708	24,295
Flounders, fresh	215,392	3,871	12,460	249	236,330	6,637	469,536	9,683	946,919	20,749
Frostfish, fresh	666	20					4,207	93	4,873	113
Haddock, fresh	330,000	3,300							775,511	11,450
Hake, fresh	170,000	850							622,806	4,245
Halibut, fresh									200	14
Herring, fresh	4,964,565	41,378			219,663	2,404	12,000	180	7,647,088	63,888
Herring, salted	126,200	1,268							1,054,100	11,106
Hickory shad, fresh	5,940	111			2,700	108			8,640	219
Kingfish, fresh	600	44			484	67	2,341	197	4,241	353
Mackerel, fresh	1,086,009	79,122	12,000	1,200	27,006	2,473	11,120	1,018	1,312,877	99,710
Mackerel, salted	194,400	20,183	6,670	667	3,200	288	13,897	939	234,067	23,364
Menhaden, fresh	126,930	644			1,200	10	18,400	137	574,336	3,977
Menhaden, salted									3,600	72
Pollock, fresh	11,000	120							155,000	1,023
Pollock, salted	9,380	109							9,380	109
Salmon, fresh	124	62							139	66
Scup, fresh	820,070	26,359	2,500	100	1,182,533	40,788	433,523	12,600	2,473,432	81,824
Sea bass, fresh	200,838	13,830	71,733	5,210	410,396	30,432	60,913	3,030	791,017	55,292
Shad, fresh	39,000	1,767			330	23	119	11	43,524	1,926
Shad, salted	2,800	104							2,800	104
Spanish mack'l, fresh	1,973	493			232	60	1,080	256	3,461	873
Smelt, fresh	3,000	346					2,000	200	10,700	1,098
Squeteague, fresh	75,091	2,604			98,420	5,731	40,670	2,453	216,571	10,929
Striped bass, fresh	6,171	806			3,880	456	14,708	1,388	24,878	2,669
Sturgeon, fresh	2,200	111							2,800	132
Swordfish, fresh							15,400	843	15,400	843
Tautog, fresh	73,325	2,394			36,037	1,241	454,188	15,916	612,393	22,310
Whiting, fresh	24,000	310					86,944	1,039	114,449	1,399
Miscellaneous, fresh	180	15			851	40			4,367	110
Refuse fish, fresh	474,000	438	200,000	100			311,400	462	1,024,400	1,093
Squid, fresh	565,000	4,432							567,800	4,466
Shrimp, fresh	2,365	860							2,365	860
Lobsters, fresh	199,297	8,354	44,675	2,234	312,300	10,129	235,099	10,861	3,273,562	144,656
Clams (soft), fresh	170,370	8,903	5,000	400			8,000	640	2,236,510	123,283
Clams (soft), salted	274,920	13,764							274,920	13,764
Quahogs, fresh	19,216	1,799	4,600	460	1,600	130	85,600	7,408	135,304	12,549
Scallops, fresh	32,500	8,475	18,357	3,820			27,850	6,405	102,357	23,869
Oysters	203,595	53,476							258,867	65,538
Algæ	39,848,786	15,774	4,075,810	7,144	23,052,450	11,718	35,211,250	14,662	117,993,900	66,034
Total	54,254,926	412,604	4,607,968	27,295	26,194,734	135,209	38,387,976	109,584	151,169,696	1,080,089

The effectiveness of the different means of capture employed in the shore fisheries is exhibited in considerable detail in the following table. Regarding fish proper, it is seen that pound nets and trap nets take by far the largest quantities of products and yield the greatest money returns. In 1889, 14,6 3,315 pounds, worth $328,386, were thus secured. Of the fish caught in this way, the mackerel is the most valuable, although herring and scup are taken in greater abundance. Hand lines and trawl lines rank second in the quantity and value of catch; they took 4,433,812 pounds, for which $109,245 was received. Cod is the most important species as regards both quantity and value secured by this means. Gill nets were used for the capture of 3,319,158 pounds, worth $95,964. Herring are the most abundant and mackerel the most valuable fish thus taken. The catch in pots, omitting the lobster, is unimportant, but including that crustacean is greater in value than that with lines and considerably larger than that with gill nets.

77.—Table showing by counties and apparatus the yield of the shore fisheries of Massachusetts in 1889.

Apparatus and species.	Essex.		Suffolk.		Norfolk.		Plymouth.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Pound nets and trap nets:								
Albacore, fresh							1,200	$15
Alewives, fresh	41,652	$406					9,176	140
Alewives, salted							2,000	40
Bluefish, fresh	100	10					144	15
Bonito, fresh	78	2						
Butter-fish, fresh	62,109	1,498					6,825	179
Cod, fresh	40,500	720						
Cunners, fresh	250	7						
Eels, fresh	223	15					750	55
Flounders, fresh	254	8					1,947	43
Herring, fresh	1,552,460	11,273					40,000	108
Herring, salted	73,000	730						
Kingfish, fresh							816	45
Mackerel, fresh	98,367	6,624					6,333	953
Menhaden, fresh	175,000	1,153					22,175	24
Menhaden, salted	3,600	72						
Pollock, fresh	7,000	61						
Pollock, salted	15	4						
Salmon, fresh							1,560	48
Scup, fresh	37	5						
Sea bass, fresh	548	23						
Shad, fresh							41	19
Spanish mackerel, fresh							609	49
Squeteague, fresh							55	6
Striped bass, fresh							600	21
Sturgeon, fresh							1,465	131
Tautog, fresh	2,500	40					1,005	10
Whiting, fresh	3,336	55						
Miscellaneous fish, fresh							30,000	30
Refuse fish, fresh								
Total	2,061,029	22,706					126,701	1,931
Gill nets:								
Bluefish, fresh							17,089	1,662
Bonito, fresh							365	30
Butter-fish, fresh					235	$28	3,515	157
Cod, fresh	6,000	120						
Cunners, fresh					5,590	280		
Flounders, fresh	6,000	120						
Herring, fresh	491,200	5,158	50,000	$750			4,000	12
Herring, salted	192,200	2,487	640,000	6,400	1,200	24	21,000	187
Mackerel, fresh	32,675	4,250			450	30	10,950	1,129
Mackerel, salted							4,700	378
Menhaden, fresh	96,000	960					8,931	69
Scup, fresh							867	32
Shad, fresh							3,527	102
Spanish mackerel, fresh							135	45
Smelt, fresh							1,700	102
Squeteague, fresh							1,781	92
Striped bass, fresh							64	13
Tautog, fresh							445	37
Total	824,075	13,095	690,000	7,150	7,475	362	79,069	4,047

77.—Table showing by counties and apparatus the yield of the shore fisheries of Massachusetts in 1889—Cont'd.

Apparatus and species.	Essex.		Suffolk.		Norfolk.		Plymouth.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Seines:								
Alewives, fresh	64,080	$520					12,250	$62
Alewives, salted							80,800	1,810
Herring, fresh	7,200	75						
Mackerel, salted	4,200	373						
Menhaden, fresh	118,200	933					7,500	47
Refuse fish, fresh	9,000	63						
Total	202,680	1,964					100,550	1,919
Fyke nets:								
Flounders, fresh	500	$10						
Trammel nets:								
Alewives, fresh							9,268	$93
Butter-fish, fresh					300	$36		
Cunners, fresh							1,250	63
Herring, salted					500	10		
Total					800	46	10,518	156
Snap nets, dip nets, etc.:								
Alewives, fresh							236,285	3,105
Alewives, salted							89,950	1,414
Cunners, fresh	45,800	1,622	212,000	$10,600			9,000	630
Eels, fresh			50,340	4,747				
Herring, fresh	306,000	2,550						
Total	351,800	4,172	271,340	15,347			335,235	5,149
Trawl lines and hand lines:								
Bluefish, fresh							66,970	6,027
Cod, fresh	698,700	15,439					154,723	3,132
Cod, salted	700	16						
Cunners, fresh							30,505	2,221
Flounders, fresh	4,500	128						
Haddock, fresh	364,900	6,801					80,611	1,349
Hake, fresh	452,800	3,395						
Halibut, fresh							200	14
Mackerel, fresh	1,750	100			200	15	26,017	2,796
Mackerel, salted							7,000	536
Pollock, fresh	137,000	1,442						
Scup, fresh							32,379	1,897
Sea bass, fresh							47,100	2,785
Smelt, fresh	4,000	450						
Tautog, fresh							46,933	2,591
Total	1,664,350	27,771			200	15	492,438	23,348
Pots:								
Cunners, fresh	28,000	910					8,000	500
Eels, fresh	17,277	1,265					1,262,628	45,694
Lobsters, fresh	541,413	31,298	678,150	36,086				
Total	586,690	33,473	678,150	36,086			1,270,628	46,194
Harpoons and spears:								
Eels, fresh							5,110	363
Miscellaneous:								
Clams (soft), fresh	1,248,600	70,860	542,540	25,181			272,000	17,299
Quahogs							24,288	2,752
Oysters							55,272	12,062
Scallops							23,650	5,169
Squid	2,800	34						
Algæ	410,000	575			3,525,490	7,127	11,870,114	9,034
Total	1,651,400	71,469	542,540	25,181	3,525,490	7,127	12,245,324	46,316
Grand total	7,342,524	174,060	2,182,030	83,764	3,533,965	7,550	14,665,573	129,423

77.—Table showing by counties and apparatus the yield of the shore fisheries of Massachusetts in 1889—Cont'd.

Apparatus and species.	Barnstable.		Nantucket.		Dukes.		Bristol.		Total for State.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Pound nets and trap nets:										
Albacore, fresh	73,500	$276							74,700	$291
Alewives, fresh	367,680	5,025			28,100	$370	484,300	$7,381	930,908	13,322
Alewives, salted	45,000	750							47,000	790
Bluefish, fresh	33,134	3,116			15,304	1,416	14,031	1,095	62,713	5,652
Bonito, fresh	25,870	731			163,008	7,180	2,683	118	191,639	8,031
Bonito, salted	1,400	88							1,400	88
Butter-fish, fresh	188,680	5,769			204,765	7,947	175,695	4,329	698,074	19,722
Cod, fresh	61,475	1,032			400	16	175	7	102,550	1,775
Cunners, fresh									250	7
Eels, fresh	5,600	325			7,000	360	11,021	391	24,594	1,146
Flounders, fresh	84,530	1,437			184,906	5,104	249,111	5,191	520,748	11,783
Frostfish, fresh							4,207	93	4,207	93
Herring, fresh	4,524,665	40,008			219,663	2,404			6,336,788	53,793
Herring, salted	126,200	1,268							199,200	1,998
Hickory shad, fresh	5,940	111			2,700	108			8,640	219
Kingfish, fresh	600	44			484	67	2,341	197	4,241	353
Mackerel, fresh	991,785	71,406			19,341	1,676	7,660	638	1,123,986	81,297
Mackerel, salted	133,640	10,774			3,200	288			136,840	11,062
Menhaden, fresh	117,030	588			1,200	10	18,400	137	333,805	1,912
Menhaden, salted									3,600	72
Pollock, fresh	11,000	120							18,000	181
Pollock, salted	330	9							330	9
Salmon, fresh	124	62							139	66
Scup, fresh	753,081	23,313			1,146,658	33,818	123,758	3,309	2,025,057	60,488
Sea bass, fresh	86,408	6,290			361,636	26,526	12,893	638	460,974	33,459
Shad, fresh	38,900	1,759			330	23			39,778	1,805
Shad, salted	2,800	104							2,800	104
Spanish mackerel, fresh	1,925	481			232	60	1,057	246	3,255	806
Smelt, fresh	3,000	346							3,000	346
Squeteague, fresh	69,997	2,227			98,420	5,731	32,000	1,916	201,026	9,923
Striped bass, fresh	1,567	166			3,880	456	4,358	333	9,860	961
Sturgeon, fresh	2,200	111							2,800	132
Tautog, fresh	42,835	1,383			24,412	881	67,418	1,969	136,130	4,364
Whiting, fresh	24,000	310					81,080	968	108,585	1,328
Miscellaneous fish, fresh					851	40			4,187	95
Refuse fish, fresh	474,000	438					307,511	445	811,511	913
Total	8,298,896	179,867			2,546,990	94,481	1,599,699	29,401	14,633,315	328,386
Seines:										
Alewives, fresh									76,330	582
Alewives, salted	541,600	8,049							622,400	9,859
Flounders, fresh	3,410	58	12,460	$249	51,424	1,533			67,294	1,840
Herring, fresh	39,000	119							46,200	194
Mackerel, salted									4,200	373
Menhaden, fresh									125,700	980
Scup, fresh					15,000	2,875			15,000	2,875
Miscellaneous fish, fresh	180	15							180	15
Refuse fish, fresh									9,000	63
Total	584,190	8,241	12,460	249	66,424	4,408			966,304	16,781
Gill nets:										
Bluefish, fresh	118,175	10,124			2,210	217	10,012	996	147,486	12,999
Bonito, fresh	2,062	96							2,427	126
Butter-fish, fresh	3,227	102			20,535	1,796	27,902	1,005	55,414	3,088
Cod, fresh	300	18							6,300	138
Cunners, fresh									5,590	280
Flounders, fresh									6,000	120
Herring, fresh	400,900	1,251					12,000	180	958,100	7,351
Herring, salted									854,400	9,098
Mackerel, fresh	85,810	7,028	12,000	1,200	5,750	615	2,760	310	150,395	14,562
Mackerel, salted	60,760	9,409	6,670	667			13,597	918	85,727	11,372
Menhaden, fresh	9,900	56							114,831	1,085
Scup, fresh	21,200	1,272	2,500	100	20,875	4,095	280,300	8,447	325,742	13,946
Sea bass, fresh	56,560	4,768			48,760	3,906	48,020	2,392	153,340	11,066
Shad, fresh	100	8					119	11	3,746	121
Spanish mackerel fresh	48	12					23	10	206	67
Smelt, fresh									1,700	102
Squeteague, fresh	5,094	377					8,670	537	15,545	1,006
Striped bass, fresh	4,604	640					10,350	1,055	15,018	1,708
Tautog, fresh					6,925	219	200,068	7,285	207,436	7,541
Whiting, fresh							5,864	71	5,864	71
Refuse fish, fresh			200,000	100			3,889	17	203,889	117
Total	768,740	35,161	221,170	2,067	105,055	10,848	623,574	23,234	3,319,158	95,964

77.—Table showing by counties and apparatus the yield of the shore fisheries of Massachusetts in 1889—Cont'd.

Apparatus and species.	Barnstable.		Nantucket.		Dukes.		Bristol.		Total for State.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Fyke nets:										
Butter-fish, fresh	2,650	$82							2,650	$82
Cunners, fresh	2,340	210							2,340	210
Flounders, fresh							9,700	$254	10,200	264
Scup, fresh							29,465	844	29,465	844
Total	4,990	292					39,165	1,098	44,655	1,400
Trammel nets:										
Alewives, fresh									9,268	93
Butter-fish, fresh									300	36
Cunners, fresh									1,250	63
Herring, salted									500	10
Total									11,318	202
Snap nets, dip nets etc.:										
Alewives, fresh	779,900	12,071							1,016,185	15,176
Alewives, salted	486,000	10,153							575,950	11,567
Cunners, fresh									266,800	12,852
Eels, fresh									59,340	4,747
Herring, fresh									306,000	2,550
Total	1,265,206	22,224							2,224,275	46,892
Trawl lines and hand lines:										
Bluefish, fresh	23,890	2,321	20,954	$1,676					111,814	10,024
Cod, fresh	597,935	8,839	10,000	250	2,800	$142	119,500	2,390	1,583,658	30,192
Cod, salted	371,270	13,123	103,209	2,785	63,000	1,890			538,179	17,814
Cunners, fresh	13,360	1,125							43,865	3,346
Flounders, fresh	25,352	431					5,725	138	35,577	697
Frostfish, fresh	666	20							666	20
Haddock, fresh	330,000	3,300							775,511	11,450
Hake, fresh	170,000	850							622,800	4,245
Halibut, fresh									200	14
Mackerel, fresh	8,414	668			1,415	182	700	70	38,496	3,851
Mackerel, salted							300	21	7,300	557
Pollock, fresh									137,000	1,442
Pollock, salted	9,050	100							9,050	100
Scup, fresh	45,789	1,774							78,168	3,671
Sea bass, fresh	57,870	2,772	71,733	5,210					176,703	10,767
Smelt, fresh							2,000	200	6,000	650
Tautog, fresh	30,490	1,011			4,700	141	186,702	6,662	268,825	10,405
Total	1,684,086	36,354	205,896	9,921	71,915	2,355	314,927	9,481	4,433,812	109,245
Pots:										
Cunners, fresh									28,000	910
Eels, fresh	180,175	9,838	20,000	1,000	38,000	1,140	12,012	811	275,464	14,554
Lobsters, fresh	199,297	8,354	44,675	2,234	312,300	10,129	235,099	10,861	3,273,562	144,656
Total	379,472	18,192	64,675	3,234	350,300	11,269	247,111	11,672	3,577,026	160,120
Harpoons and spears:										
Eels, fresh	49,800	2,845					10,400	640	65,310	3,848
Flounders, fresh	102,100	1,945					205,000	4,100	307,100	6,045
Swordfish, fresh							15,400	843	15,400	843
Total	151,900	4,790					230,800	5,583	387,810	10,736
Miscellaneous:										
Clams (soft), fresh	170,370	8,903	5,000	400			8,000	640	2,236,510	123,283
Clams (soft), salt'd	274,920	13,764							274,920	13,764
Quahogs	19,216	1,799	4,600	460	1,600	130	85,600	7,408	135,304	12,549
Oysters	203,595	53,476							258,867	65,538
Scallops	32,500	8,475	18,357	3,820			27,850	6,405	102,357	23,869
Shrimp	2,365	860							2,365	860
Squid	565,000	4,432							567,800	4,466
Algæ	39,848,786	15,774	4,075,810	7,144	23,052,450	11,718	35,211,250	14,662	117,993,900	66,034
Total	41,116,752	107,483	4,103,767	11,824	23,054,050	11,848	35,332,700	29,115	121,572,023	310,363
Grand total	54,254,926	412,604	4,607,968	27,295	26,194,734	135,209	38,387,976	109,584	151,169,696	1,090,089

The following table graphically exhibits the relative importance of the various means of capture employed in the shore fisheries of Massachusetts. The table shows the wide differences which exist between the percentages of quantity and value of products obtained in the different forms of apparatus.

78.—Table showing the relative quantity and value of yield in each principal form of apparatus of capture employed in the shore fisheries of Massachusetts in 1889.

Apparatus.	Percentage.	
	Quantity.	Value.
Seines	.64	1.55
Gill nets	2.19	8.89
Pound nets and trap nets	9.68	30.40
Fyke nets	.03	.13
Snap nets and dip nets	1.47	4.34
Hand and trawl lines	2.93	10.12
Pots	2.37	14.83
Harpoons and spears	.26	.99
Miscellaneous	80.43	28.75
Total	100.00	100.00

The various counties fare very differently in the item of receipts from the sale of fishery products. This fact is brought out in the following table. In Essex County, for instance, the fishermen take $1,256 worth of products for each $100 invested in boats; in Suffolk County they stock $1,117 on the same basis, while in Plymouth County only $215 is the average. The variation in the item of investment in apparatus is quite as marked. Suffolk County leads with products valued at $1,214 for each $100 expended for apparatus; Barnstable County ranks last, with only $226. The average stock per man is greatest in Dukes and Suffolk counties ($528 and $524, respectively) and least in Norfolk County ($101).

The relative effectiveness of each kind of apparatus in each county is shown. Pound nets and trap nets yield a larger percentage of returns than any other devices in Barnstable, Dukes, and Bristol counties; pots lead in Suffolk County; and such miscellaneous forms as rakes, hoes, dredges, etc., are the most important in Essex, Norfolk, Plymouth, and Nantucket counties. Seines take an insignificant part in the fisheries of all the counties, but are most important in Dukes County, where they are credited with 3 per cent of the entire value of the shore products. Gill nets are most effective in Bristol County, where they yield 21 per cent of the returns, but in no other county do they represent as much as 9 per cent of the income of the fishermen. In Suffolk County snap nets, dip nets, and other minor nets took 18 per cent of the value of the output. Lines in Nantucket, Plymouth, and Essex counties yielded, respectively, 36, 18, and 16 per cent of the returns.

79.—Table showing by counties certain averages and percentages of the shore fisheries of Massachusetts in 1889.

Counties.	Value of catch per each $100 invested in boats.	Value of catch per each $100 invested in apparatus.	Value of catch per each man employed.	Percentage of value of yield in principal forms of apparatus.									
				Total.	Pound nets and trap nets.	Seines.	Gill nets.	Fyke nets.	Snap nets, dip nets, etc.	Lines.	Pots.	Harpoons and spears.	Miscellaneous.
Essex	$1,256	$466	$385	100.00	13.00	1.12	7.50	.01	2.39	15.90	19.16	.....	40.92
Suffolk	1,117	1,214	524	100.00	.....	.....	8.54	.....	18.32	.....	43.08	.....	30.06
Norfolk	244	378	101	100.00	.....	.....	4.79	.....	.....	.20	.....	.....	95.01
Plymouth	215	426	225	100.00	1.49	1.48	3.13	.....	3.98	18.04	35.69	.28	35.91
Barnstable	365	226	224	100.00	43.59	2.00	8.52	.07	5.39	8.81	4.41	1.16	26.05
Nantucket	910	433	337	100.00	.....	.91	7.57	.....	.....	36.35	11.85	.....	43.32
Dukes	497	460	528	100.00	69.88	3.26	8.02	.....	.....	1.74	8.34	.....	8.76
Bristol	418	589	357	100.00	26.83	.....	21.20	.06	.....	8.65	10.65	5.10	26.57

The relative value of each fishery product is shown in great detail in the next table, the specification being by counties. The figures represent the percentage of value of each product to the total value of the catch in each county.

80.—Table showing by counties the percentage of value of each species to the total yield of the shore fisheries of Massachusetts in 1889.

Species.	Essex.	Suffolk.	Norfolk.	Plymouth.	Barnstable.	Nantucket.	Dukes.	Bristol.
Albacore, fresh				.01	.07			
Alewives, fresh	.53			2.63	4.14		.27	6.74
Alewives, salted				2.52	4.59			
Bluefish, fresh	.01			5.95	3.77	6.14	1.21	1.91
Bonito, fresh				.02	.20		5.31	.11
Bonito, salted					.02			
Butter-fish, fresh	.86		.85	.26	1.44		7.20	4.87
Cod, fresh	9.32			2.42	2.40	.92	.12	2.19
Cod, salted	.01				3.18	10.20	1.40	
Cunners, fresh	1.45	12.65	3.71	2.25	.32			
Eels, fresh	.73	5.67		.71	3.15	3.66	1.11	1.68
Flounders, fresh	.15			.03	.94	.91	4.91	8.84
Frostfish or tomcod, fresh					.01			.08
Haddock, fresh	3.90			1.04	.80			
Hake, fresh	1.95				.21			
Halibut, fresh				.01				
Herring, fresh	10.91	.90		.09	10.03		1.78	.16
Herring, salted	1.84	7.64	.45	.14	.31			
Hickory shad, fresh					.03		.08	
Kingfish, fresh				.04	.01		.05	.18
Mackerel, fresh	6.28		.59	3.77	19.18	4.40	1.83	.93
Mackerel, salted	.21			.71	4.89	2.44	.21	.86
Menhaden, fresh	1.75			.11	.16		.01	.13
Menhaden, salted	.04							
Pollock, fresh	.86				.03			
Pollock, salted					.03			
Salmon, fresh					.01			
Scup, fresh				1.53	6.39	.37	30.16	11.50
Sea bass, fresh				2.15	3.35	19.09	22.51	2.77
Shad, fresh	.01			.08	.43		.02	.01
Shad, salted					.02			
Spanish mackerel, fresh				.05	.12		.04	.23
Smelt, fresh	.26			.08	.08			.18
Squeteague, fresh				.11	.63		4.24	2.24
Striped bass, fresh				.01	.19		.34	1.27
Sturgeon, fresh				.02	.03			
Swordfish, fresh								.77
Tautog, fresh				2.13	.58		.92	14.52
Whiting, fresh	.02			.01	.07			.95
Miscellaneous fish, fresh	.03				.01		.03	
Refuse fish, fresh	.04			.02	.11	.37		.42
Squid, fresh	.02				1.07			
Shrimp, fresh					.21			
Lobsters, fresh	17.92	43.08		35.31	2.02	8.18	7.49	9.91
Clams (soft), fresh	40.57	30.06		13.37	2.16	1.47		.58
Clams (soft), salted					3.34			
Quahogs, fresh				2.13	.44	1.69	.09	6.75
Scallops, fresh				3.99	2.05	13.99		5.84
Oysters				9.32	12.96			
Algæ	.33		94.40	6.98	3.82	26.17	8.67	13.38
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The following tables show three different phases of the bait fishery prosecuted from the shores of Massachusetts. In the first table the extent and value of this fishery is shown by counties and apparatus; in the second table an exhibit is made by counties and species; and the third is a presentation by apparatus and species.

A consideration of these tables demonstrates that Barnstable County is the most important from the standpoint of production of bait, while Essex County comes next. In both of these counties, as well as in Bristol County, pound nets and trap nets are the important factors in obtaining bait; indeed, the third table shows that of the 8,592,464 pounds of fish and squid obtained in the shore fisheries of Massachusetts and sold for bait, 6,980,684 pounds were the product of the pound-net fishery; while gill nets, the next most productive form, took only 406,000 pounds.

It is noteworthy that nearly one-half of the products obtained in the pound-nets of Massachusetts are sold for bait to vessels engaged, for the most part, in the offshore-bank fisheries. To be more precise, it may be stated that the entire product of the pound-net fishery of Massachusetts amounted, in 1889, to 14,633,315 pounds, of which, as has been shown, 6,980,684 pounds were sold for bait. It is also noteworthy that the catch of the pound nets in this region shows a very small percentage of what are commonly denominated "game fish." So far as bait species are concerned, herring take precedence, 5,739,400 pounds having been sold. Squid is the next important species, 567,800 pounds having been taken for bait in pound nets in 1889; none were obtained by other forms of apparatus.

For some years Barnstable Bay, particularly on the Cape Cod side, has been a famous bait resort for vessels employed in the ocean fisheries. The importance to the bank fisheries of this resource for bait supply for vessels sailing from Cape Cod ports, Boston, and the north shore of Massachusetts Bay, will be better understood when it is stated that enough bait was obtained in 1889 in Barnstable County to supply 20 barrels each to more than 1,500 sail of vessels.

81.—Table showing by counties and apparatus the quantities of fish and squid taken in the shore fisheries of Massachusetts in 1889 and sold for bait.

Apparatus.	Essex.		Plymouth.		Barnstable.		Bristol.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Pound nets and trap nets	1,301,352	$9,460	9,176	$140	5,513,556	$42,704	156,600	$284	6,980,684	$52,588
Seines	189,480	1,528							189,480	1,528
Gill nets	376,000	3,449			30,000	375			406,000	3,824
Dip nets	306,000	2,550	166,500	2,237	543,800	9,008			1,016,300	13,795
Total	2,172,832	16,987	175,676	2,377	6,087,356	52,087	156,600	284	8,592,464	71,735

82.—Table showing by counties and species the quantities of fish and squid taken in the shore fisheries of Massachusetts in 1889 and sold for bait.

Species.	Essex.		Plymouth.		Barnstable.		Bristol.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives, fresh	106,232	$926	175,676	$2,377	781,956	$12,129			1,063,864	$15,432
Herring, fresh	1,689,200	13,039			4,643,400	35,179			6,332,600	48,218
Menhaden, fresh	370,000	2,911			87,000	342	9,400	$68	466,400	3,321
Menhaden, slivers	3,600	72							3,600	72
Squid, fresh	2,800	34			565,000	4,432			567,800	4,466
Miscellaneous fish, fresh	1,000	5			10,000	5	147,200	216	158,200	226
Total	2,172,832	16,987	175,676	2,377	6,087,356	52,087	156,600	284	8,592,464	71,735

83.—Table showing by apparatus and species the quantities of fish and squid taken in the shore fisheries of Massachusetts in 1889 and sold for bait.

Species.	Pound nets and trap nets.		Seines.		Gill nets.		Dip nets.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives, fresh	259,484	$3,292	64,080	$520	30,000	$375	710,300	$11,245	1,063,864	$15,432
Herring, fresh	5,739,400	43,104	7,200	75	280,000	2,489	306,000	2,550	6,332,600	48,218
Menhaden, fresh	252,200	1,428	118,200	933	96,000	960			466,400	3,321
Menhaden, slivers	3,600	72							3,600	72
Squid, fresh	567,800	4,466							567,800	4,466
Miscellaneous fish, fresh	158,200	226							158,200	226
Total	6,980,684	52,588	189,480	1,528	406,000	3,824	1,016,300	13,795	8,592,464	71,735

RESULTS OF ARTIFICIAL PROPAGATION.

No subject connected with the fisheries of New England seems to be of greater consequence than the results which apparently have been secured through the hatching and planting of millions of cod fry by the U. S. Fish Commission in the coastal waters of this region. When this work was first inaugurated there was much skepticism among the fishermen, who believed that little could be accomplished by man in this direction. However, much to the surprise and advantage of those most interested, young cod have made their appearance in great numbers on many parts of the coast, particularly off southern New England, where, for at least a quarter of a century, they have been either very rare or unknown; and it seems to be demonstrated that as a result of this work a new and important summer cod fishery has been established on Nantucket Shoals and on the fishing-grounds immediately south.

During the summer of 1890 the Fish Commission received information showing that up to the first of August large catches of cod of small or medium size had been made by the fleet of schooners fishing south or east of Nantucket. This fishery was begun by a few small vessels in 1889, one of which, the *Eliza*, landed about 300,000 pounds of small cod taken in the season of that year. From all the data available, at least 4,000,000 pounds of codfish appear to have been taken on these grounds in the spring and summer of 1890, previous to the last of July. These fish are reported to be much in favor in the markets, since they are of even size and in good demand at restaurants and hotels, where they are prepared for food under the name of "scrod."

Among other references to the appearance of young cod along the coast, which are concededly those hatched by the Fish Commission, is the following:

Mr. George A. Griffin, of Wakefield, Rhode Island, writing under the date of December 12, 1890, says:

> There are none of our fishermen that have made any business of cod fishing for 15 or 20 years past, so they were ill prepared to catch or cure when the fish struck on. But they managed to secure, as near as I can calculate without taking a great deal of pains, some 6,000 to 7,500 pounds of cod. The fish struck on at the pier [Narragansett Pier] the 20th of October. Capt. Taylor's boy and a friend went out in a small boat from South Pier and caught about 20 or 30 fish. The next day they caught about 100. This waked up the older fishermen and they caught from 100 to 300 fish per day to a boat according to the weather, etc. * * * They were all caught within a quarter of a mile off the pier shore and half a mile or so off Point Judith. * * * The fish would average, I think, about 6 pounds, and were of a very dark color, with once in a while a large, coarse, light-colored fish, which resembled more the common old fish we used to catch here.

The observations of Mr. Willard Nye, of New Bedford, Massachusetts, disclosed the occurrence of codfish in the shoal waters at the mouth of Buzzards Bay and to the westward in greater numbers than for many years. The fish were mostly caught in pound nets and trap nets as far west as Sakonnet Point, and numbers were also taken with hook and line in various localities. Mr. Nye states that cod fishing inside Buzzards Bay is something new, even to the oldest inhabitant, and he does not doubt that the fish secured are those artificially propagated by the U. S. Fish Commission. The fish are of fine quality, very active, and are of two sizes, weighing 4 and 6 pounds each, and are school cod and not the rock cod, specimens of which are caught every year.

THE FISH TRADES OF BOSTON AND GLOUCESTER.

A noticeable feature of the fishery interests of Massachusetts is the great volume of trade entering at Gloucester and Boston, which are the receiving and distributing centers of marine food products for New England, to such an extent that they practically control this branch of commerce. Maine has extensive canning interests and produces large quantities of salt and fresh fish, but has no very important trade center for fishing products, and the bulk of its output is marketed in Massachusetts. For this reason the tables showing the fish trade of the two leading ports of New England will throw an instructive side light upon the fisheries of this region.

Tables 84 and 85 make an exhibit of the fish trade of Gloucester and Boston. Heretofore no statistics of this nature have been prepared, and there has been no definite knowledge of the extent of the fish trade in these ports. The magnitude of the trade will probably be a matter of considerable surprise to many.

Gloucester is the leading fish-producing center of the United States; its large and fine fleet of vessels engages in all the leading branches of ocean fishery except the mammal fisheries, from the Gulf of Mexico to Iceland; and its trade is chiefly in the products received from its own vessels, though considerable quantities of fish are obtained from other New England States and from the British provinces.

Boston, while having a much smaller fleet than Gloucester, is a great distributing center of fishery products. It receives contributions from many sources. What is commonly denominated the market fishery of New England centers at Boston, where the fleets of the leading fishing ports resort to sell their catch. In addition to this, Boston imports from the British North American provinces, from various countries of Europe, and from Pacific and Atlantic ports, all kinds of fishery products. Its trade is very extensive, as will appear by the tables.

From the table showing the extent of the wholesale fish trade of Gloucester it will be seen that the handling of salt fish is the most important branch of the business. This gave employment to 833 persons; $1,769,138 was invested in shore property and cash capital, and 114,296,733 pounds of raw products, worth $3,427,966, were handled, from which 92,833,991 pounds of boneless and other kinds of cured fish, with a value of $4,193,284, were prepared. The enhancement in value is thus $765,318, this sum representing the gross profits of the trade.

The fresh-fish trade is the next in importance, although much less extensive than the preceding. The fish handled amounted to 11,671,331 pounds, valued at $491,636, and the quantity of fish sold was 10,229,994 pounds, for which $610,971 was received, the gross profits being $119,335.

The business of smoking fish utilized 3,410,205 pounds of fish, worth $127,387, which, when smoke-cured, weighed 2,259,346 pounds, with a market value of $169,266, the gross profit amounting to $41,879.

The difference between the quantities of fish bought and sold in the three foregoing trades is due to the waste in the process of curing, preparing, etc., as will be readily understood.

The trade in and manufacture of fish oil is an important feature of the fish trade of Gloucester. The table shows 8,278,513 pounds of livers, crude oil, etc., purchased for $216,077 by the 8 wholesale dealers, who manufactured and handled 912,728 gallons of oil, for which they received $283,754.

[illegible]

[illegible]

14. Firms carrying on several of the wholesale fish trades and related industries of Gloucester, Mass., in 1905.

Trades	No. of firms	Persons engaged			Capital invested			Purchased		Sold	
		Officers of firms	Clerks	All others	Total	Fixed	Cash and stock	Pounds	Value	Pounds	Value
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

The table shows that in 1889 208,000,000 pounds of fish products passed through the hands of the wholesale firms of Boston, and by the processes of handling and manufacturing the value of the products was increased by the sum of $1,431,480—the gross profits of the trade. The total fish trade of Boston, based on the value of products as sold, reaches an aggregate of $11,100,259.

85.—Table showing the extent of the wholesale fish trades of Boston, Mass., in 1889.

Trades.	No. of firms.	Persons engaged.				Wages paid in 1889.	Capital invested.		
		Capitalists.	Clerks.	All others.	Total.		Plants.	Cash.	Total.
Fresh fish	44	89	52	141	326	$136,940	$615,350	$448,000	$1,063,350
Salt fish	24	34	67	244	369	150,262	405,975	733,600	1,139,575
Oyster	14	21	16	100	151	67,086	137,875	144,500	282,375
Lobster	11	17	7	39	74	31,152	67,165	65,000	132,165
Commission	12	19	38	.....	69	31,128	71,600	765,000	836,600
Glue and isinglass	5	7	5	71	88	19,626	72,700	135,000	207,700
Total	110	187	185	595	1,077	436,194	1,370,665	2,291,100	3,661,765

Trades.	Raw products handled.			Manufactured products handled or prepared.				Enhancement in value.
	Pounds.	Price paid.	Price received.	Smoked and boneless.	Canned.	Price paid.	Price received.	
				Pounds.	*Cases.*			
Fresh fish	*82,697,368	$2,639,346	$3,165,110	.....	.....	.....	.....	$525,764
Salt fish	37,786,685	1,632,688	1,909,362	17,384,900	89,985	$1,013,313	$1,207,520	470,881
Oyster	†8,090,838	1,050,304	1,220,823	.....	.....	.....	.....	170,519
Lobster	8,213,264	557,004	694,639	.....	.....	.....	.....	137,635
Commission	52,350,500	.....	2,657,650	.....	.....	.....	.....	.....
Glue and isinglass	19,151,000	118,474	.....	‡3,757,966	.....	.....	245,155	126,681
Total	208,289,655	5,997,816	9,647,584	21,142,866	89,985	1,013,313	1,452,675	1,431,480

* In the figures for this trade the following products have not been included: 135,400 buckets of livers, cost price $8,753, selling price $14,572.

† 1,155,834 bushels.

‡ Glue, isinglass, poultry food, and fertilizer.

THE FISHING-GROUNDS.

The following table is presented to show the relative productiveness of the Atlantic fishing-grounds resorted to by vessels sailing from Gloucester, Mass., so far as this can be demonstrated from the reports obtained from vessels landing their fares at Gloucester. It may be stated at the outset, however, that the cargoes do not represent the entire catch of the Gloucester fleet, since large quantities of fish are landed elsewhere, notably at Boston. Nevertheless, the table will serve the purpose for which it has been prepared, particularly if considered in connection with Table 87, which covers receipts at Boston.

It has been deemed advisable to show under distinct headings the quantities of fish taken on the grounds on either side of the sixty-fifth meridian; those west of this meridian are for the most part off the coast of the United States; those east of it are in the open Atlantic or off the coasts of the British North American Provinces.

86.—Table showing by fishing-grounds the quantities of fish landed at Gloucester, Mass., in 1889, by New England fishing vessels.

Species.	Fishing-grounds west of 65° W. longitude.											
	Offshore grounds.						Inshore grounds.					Total.
	Nantucket Shoals.	South Channel.	Georges Bank.	Fippennies Bank.	Cashes Bank.	Browns Bank.	Shore, general.	Ipswich Bay.	Off Chatham.	Jeffreys Ledge.	Middle (or Stellwagen) Bank.	
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Cod, fresh	51,000	6,000	373,300	.....	20,000	72,000	1,971,955	50,700	.....	.....	11,000	2,555,955
Cod, salted	1,061,700	56,100	15,464,001	.....	84,800	138,000	588,800	11,000	.....	.....	.....	17,404,401
Cusk, fresh	.....	16,000	42,000	23,600	72,000	.....	21,170	.....	.....	25,000	.....	199,770
Cusk, salted	2,000	.....	18,300	.....	52,400	.....	92,300	.....	.....	.....	.....	165,000
Haddock, fresh	.....	.....	1,147,000	.....	.....	.....	150,170	.....	.....	.....	6,300	1,303,470
Haddock, salt	.....	.....	.....	.....	.....	.....	10,000	.....	.....	.....	.....	10,000
Hake, fresh	.....	5,000	29,000	.....	10,000	.....	448,620	.....	.....	.....	.....	492,620
Hake, salted	10,000	9,600	95,900	.....	46,000	.....	194,300	.....	.....	.....	.....	355,800
Halibut, fresh	44,000	.....	945,660	.....	.....	26,600	.....	.....	.....	.....	10,400	1,026,660
Herring, salted	.....	.....	.....	.....	.....	.....	556,400	.....	.....	.....	.....	556,400
Mackerel, salted	.....	.....	.....	.....	.....	.....	1,091,600	.....	.....	.....	120,900	1,212,500
Pollock, fresh	.....	.....	.....	.....	.....	.....	855,273	.....	.....	2,240,250	.....	3,095,523
Pollock, salted	21,000	.....	15,000	.....	.....	.....	164,200	.....	310,000	.....	.....	510,200
Swordfish, fresh	.....	.....	.....	.....	.....	.....	18,840	.....	.....	.....	.....	18,840
Total	1,189,700	92,700	18,130,161	23,600	285,200	236,600	6,163,628	61,700	310,000	2,265,250	148,600	28,907,139

Species.	Fishing-grounds east of 65° W. longitude.									Grand total.
	Offshore grounds.					Inshore grounds.			Total.	
	Grand Bank and Flemish Cap.*	Western Bank.	Quereau Bank.	La Have Bank.	Iceland.	Cape Shore.	Cape North.‡	Gulf of St. Lawrence generally.		
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Cod, fresh	3,000	5,000	34,000	.....	.....	.....	.....	.....	42,000	2,597,955
Cod, salted	22,533,997	4,285,333	137,410	189,135	.....	2,775,280	.....	.....	29,921,155	47,325,556
Cusk, fresh	.....	1,000	.....	9,000	.....	.....	.....	.....	10,000	209,770
Cusk, salted	.....	36,837	.....	26,711	.....	35,100	.....	.....	98,648	263,648
Haddock, fresh	.....	5,000	.....	2,000	.....	.....	.....	.....	7,000	1,310,470
Haddock, salted	.....	48,648	.....	57,652	.....	5,000	.....	.....	111,300	121,300
Hake, fresh	.....	2,000	.....	8,000	.....	.....	.....	.....	10,000	502,620
Hake, salted	.....	76,673	.....	125,361	.....	274,200	.....	.....	476,234	832,034
Halibut, fresh	5,002,500	1,250,528	728,208	125,660	.....	†49,350	51,000	.....	7,207,246	8,233,906
Halibut, salted	138,458	35,348	.....	.....	746,883	2,000	.....	.....	922,689	922,689
Herring, salted	.....	.....	.....	.....	.....	.....	.....	.....	.....	556,400
Mackerel, salted	.....	.....	.....	.....	.....	.....	.....	1,063,200	1,063,200	2,275,700
Pollock, fresh	.....	.....	.....	.....	.....	.....	.....	.....	.....	3,095,523
Pollock, salted	.....	61,402	.....	159,704	.....	.....	.....	.....	221,106	731,306
Swordfish, fresh	.....	.....	.....	.....	.....	.....	.....	.....	.....	18,840
Total	27,677,955	5,807,769	899,618	703,223	746,883	3,140,930	51,000	1,063,200	40,090,578	68,997,717

* The greater part of the salt cod and all of the fresh halibut under this head were taken on the Grand Bank.

† The term "Cape Shore" is somewhat indefinitely applied to fishing-grounds along the south side of Nova Scotia, from Cape Sable (from which the term is derived) eastward, at distances generally varying from 10 to 40 miles from the land.

‡ In some seasons fares of salt cod are received from this ground, but fares of fresh halibut are very exceptional.

In explanation of this table, it may be said that the fishery on what is termed Nantucket Shoals is carried on upon grounds at varying distances south or east of Nantucket, sometimes in relatively deep water. The fishery usually begins in April and continues until September. It may be denominated a summer cod fishery.

The fishery in the South Channel is engaged in occasionally by a few vessels which at other times fish upon Georges Bank or Browns Bank. This is also a summer fishery, and depends on the fact that during midsummer fish are generally compara-

tively scarce on Georges Bank. It may be explained that the South Channel (so called) is a westward extension of Georges Bank. It divides the great shoals on the bank from Nantucket Shoals.

The Georges Bank fishery is carried on throughout the year, although the fishery is prosecuted to a less extent in January, October, November, and December than during the rest of the season. The fleet begins operations in the latter part of January or early in February. Some of the vessels haul up in November and December. Vessels employed in catching fresh haddock and cod are most active in midwinter and in the late spring and early summer. The greater part of their catch is landed at Boston.

The fishery on Cashes Bank usually begins in April and is continued until July. It is a minor fishery and is carried on chiefly by small schooners that engage in the shore fishery in winter.

Browns Bank is resorted to in the early winter and late spring and summer by the vessels that commonly fish on Georges Bank during February, March, and April, when the "winter school" of cod is on Georges.

"Shore, general," under the head of "inshore grounds," applies to various areas along the New England coast from Block Island to the Bay of Fundy. It often happens that a vessel cruising for mackerel, swordfish, or perhaps engaged in the shore cod fishery, may in one trip visit a large number of fishing-grounds, and in some cases may cover the entire region along the coast from Block Island to near Grand Manan. It has, therefore, been found necessary to make this classification.

There is a limited fishing-ground off Cape Cod which is resorted to in the spring for pollock. Ipswich Bay is a famous cod fishing-ground in winter. Large quantities of fish taken there by the Gloucester vessels are landed elsewhere, especially at Boston. It is also beyond question that many of the fresh codfish included under the head of "shore, general" were taken in Ipswich Bay.

Fippennies Bank is an unimportant fishing-ground lying westward of Cashes, and is sometimes resorted to in summer by small schooners, which seldom make more than one or two trips.

Jeffries Ledge is visited chiefly in fall by small vessels fishing for pollock.

The following explanations may be offered concerning the fishing-grounds lying east of the sixty-fifth meridian.

In November and December certain vessels which at other seasons are engaged in fishing chiefly upon Georges Bank visit La Have for fares of fresh and salt cod. The halibut credited to this bank are in part taken east of the bank, on what is termed the La Have Ridges.

The Western Bank cod fishery is usually prosecuted most extensively in March, April, and May, though it is engaged in to a less extent in the fall and early winter. The cod-fishing vessels ordinarily sail in March, and the last of them arrive home in June. Vessels visiting the bank in fall sail in September, October, and November. The quantity of fish taken on the Western Bank varies considerably with different seasons. The amount shown in the table is smaller than the recent average annual catch by Gloucester vessels. The Western Bank, as well as La Have, has been at times quite noted as a halibut fishing-ground. In recent years, however, its value for this species has decreased materially.

Quereau Bank is not much resorted to by cod-fishing vessels from Gloucester, chiefly because of the small size and comparatively poor quality of fish on that bank. It is, however, a favorite fishing-ground for halibut, which are taken in deep water (150 to 400 fathoms) along the eastern, southern, and western edges of the bank.

Misaine Bank is seldom visited by New England fishing vessels.

Grand Bank and Flemish Cap are included under one head, for the reason that it is impracticable to designate definitely the quantity of fish taken on either, since the vessels that go to Flemish Cap usually spend a portion of their time in fishing upon the Grand Bank. The fleet resorting to the Flemish Cap is a comparatively small one, and the fishery there is carried on chiefly in May, June, and July. Some halibut are taken on the Flemish Cap and salted, but no fresh halibut are received from that bank. The fresh-halibut fishery on the Grand Bank is pursued vigorously throughout the year. The cod fishery, however, seldom or never begins before March. It is at its height from May to September. The fares arriving after September are composed for the most part of fish taken earlier in the season. The codfish received from the Grand Bank in November and December are brought in chiefly by vessels that start late in the season on their second or third fares. The cod fishery on the Bank may be considered closed in November, though some fares arrive home at a later date.

The Iceland fishing-grounds have come into prominence in recent years, and now furnish practically all the salt halibut. Vessels leave home in March and April, and return in August, September, and October. The bulk of the catch is obtained in May, June, and July.

The Cape Shore cod fishery is prosecuted in spring, summer, and autumn, beginning about April 1 and continuing until the close of the year. It is most active, however, in midsummer and early autumn, and is engaged in chiefly by vessels which, earlier in the season, may visit the Western Bank or La Have, or which in winter and early spring may find employment in the shore cod fishery off the New England coast.

The fishing-ground about Cape North, which is the northernmost point of Cape Breton Island, has in some seasons been quite noted for the number of fares of codfish obtained there. The cod fishery in this region is irregular, due largely to the fact that it is entirely a spring fishery, and operations may be interfered with or prevented by the presence of masses of drifting ice which come down from the Gulf of St. Lawrence and cover the fishing-ground. Fares of halibut have occasionally been taken in this locality.

The Gulf of St. Lawrence is not resorted to by cod-fishing vessels of New England except on very rare occasions, but it is a noted fishing-ground for mackerel, though its value as such has materially decreased in recent years. The mackerel fishery in the Gulf begins in June and generally continues until some time in October. The last vessels of the fleet generally reach the home port in November. The relatively large receipts of mackerel from this fishing-ground are due to the fact that the fares brought in at the close of the season in most cases were the entire year's catch for the vessels engaged. It may be explained that the grounds resorted to in the Gulf of St. Lawrence by American fishermen are outside the 3-mile limit, with the exception of those about the Magdalene Islands and western Newfoundland, where Americans have the right to fish inside of territorial limits.

87.—Table showing by fishing-grounds the quantities of fresh ground fish landed at Boston, Mass., in 1889, by New England fishing vessels.

Fishing-grounds.	Cod.	Haddock.	Halibut.	Hake.	Pollock.	Cusk.	Total.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Offshore:							
Western Bank	7,000	2,000	7,000	.....	.....	.....	16,000
La Have Bank	431,700	1,090,000	15,860	46,500	.....	7,100	1,591,160
Browns Bank	333,000	201,000	39,300	68,200	7,000	12,200	660,700
Georges Bank	6,400,150	13,663,500	95,683	561,150	27,010	35,550	20,783,143
Clark Bank	45,100	154,000	4,590	42,800	280	.....	246,770
Marblehead Bank	5,000	4,000	500	3,000	2,500	1,000	16,000
Cashes Bank	52,400	97,000	1,100	37,500	500	3,500	191,900
Nantucket Shoals	536,250	773,850	2,590	92,925	13,150	9,800	1,428,565
South Channel	2,935,363	5,016,300	92,870	1,612,410	187,619	42,816	9,887,378
Total	10,745,963	21,001,650	259,493	2,464,485	238,059	111,966	34,821,616
Inshore:							
Middle (Stellwagen) Bank	289,860	1,019,135	7,002	505,845	34,750	13,025	1,869,617
Tillies Bank	5,800	70,700	100	30,000	1,400	9,000	117,000
Ipswich Bay	9,000	9,100	.....	17,750	.....	.....	35,850
Jeffrey Ledge	436,280	1,296,100	15,650	727,950	312,700	36,550	2,824,330
Cape Shore	728,900	1,016,500	26,456	116,250	4,666	27,250	1,920,022
Shore, general	1,210,174	2,759,905	22,240	678,640	38,190	22,109	4,731,258
Total	2,680,014	6,171,440	71,448	2,075,535	391,706	107,934	11,498,077
Grand total	13,425,977	27,173,090	330,941	4,540,020	629,765	219,900	46,319,693

88.—Table showing by fishing-grounds and months the quantities of fresh and salt mackerel landed at Boston, Mass., in 1889 by New England fishing vessels.

Fishing-grounds.	June.		July.		August.		September.		October.		November.		Total.	
	Fresh.	Salt.	Fresh.	Salt.	Fresh.	Salt.	Fresh.	Salt.	Fresh.	Salt.	Fresh.	Salt.	Fresh.	Salt.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Barnstable Bay	.....	.....	.....	.....	19,750	.....	41,075	.....	61,275	.....	.....	.....	122,100	.....
Block Island	.....	.....	.....	19,200	.....	21,600	.....	.....	.....	.....	.....	.....	.....	40,800
Boon Island	.....	.....	.....	.....	14,800	.....	.....	.....	.....	.....	.....	.....	14,800	.....
Cape Cod Bay	14,000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14,000	.....
Chatham	6,000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6,000	.....
Eastern Shore	.....	.....	.....	.....	.....	21,000	.....	.....	.....	.....	.....	.....	.....	21,000
Garnet	.....	.....	.....	.....	.....	.....	6,500	.....	.....	.....	.....	.....	6,500	.....
Gloucester	.....	.....	16,000	.....	.....	.....	.....	.....	.....	.....	.....	.....	16,000	.....
Halfway Rock	.....	.....	.....	.....	.....	.....	13,750	.....	.....	.....	.....	.....	13,750	.....
Jeffrey Bank	.....	.....	.....	.....	10,000	.....	.....	.....	.....	.....	.....	.....	10,000	.....
Matinicus	.....	.....	.....	9,600	.....	.....	.....	.....	.....	.....	.....	.....	.....	9,600
Marblehead	.....	.....	2,000	.....	.....	.....	11,000	.....	.....	.....	.....	.....	13,000	.....
Middle Bank	.....	.....	8,500	.....	48,700	600	.....	.....	.....	.....	.....	.....	57,200	600
Minots Light	.....	.....	40,000	.....	2,500	800	88,680	.....	.....	.....	.....	.....	131,180	800
Monhegan	.....	.....	.....	1,400	.....	.....	.....	.....	.....	.....	.....	.....	.....	1,400
Nahant	.....	.....	5,500	.....	.....	.....	700	.....	.....	.....	.....	.....	6,200	.....
Plymouth	.....	.....	500	.....	42,050	.....	1,000	.....	.....	.....	.....	.....	43,550	.....
Provincetown	6,000	.....	16,000	.....	7,450	.....	.....	.....	.....	.....	.....	.....	29,450	.....
Race Point	.....	.....	4,000	.....	7,450	.....	800	.....	.....	.....	.....	.....	12,250	.....
Shore Grounds	.....	.....	.....	.....	.....	.....	900	91,600	.....	13,000	.....	36,600	900	141,200
Swampscott	.....	.....	.....	.....	1,100	.....	.....	.....	.....	.....	.....	.....	1,100	.....
Thatcher Island	.....	.....	13,000	.....	1,500	.....	8,000	.....	.....	.....	.....	.....	22,500	.....
Total	28,000	.....	105,500	30,200	155,300	44,000	172,405	91,600	61,275	13,000	.....	36,600	520,480	215,400

92.—Table showing by counties the number and nationality of persons employed in the vessel fisheries of Rhode Island in 1889.

Counties.	Number and nationality of men on fishing vessels.			Number and nationality of men on transporting vessels.		
	Americans.	All others.	Total.	Americans.	All others.	Total.
Providence	34	.....	34	.....	.....	.....
Bristol	21	.....	21	.....	.....	.....
Newport	319	2	321	12	.....	12
Total	374	2	376	12	.....	12

93.—Table showing by counties the number, tonnage, value, and outfits of vessels employed in the vessel fisheries of Rhode Island in 1889.

Counties.	Vessels.							
	Fishing.				Transporting.			
	No.	Tonnage.	Value.	Value of outfit.	No.	Tonnage.	Value.	Value of outfit.
Providence	12	126.49	$15,700	$2,599	.....	.....	.....	.....
Bristol	8	79.59	12,800	1,901	.....	.....	.....	.....
Newport	42	1,195.97	165,825	21,885	7	82.74	$2,625	$400
Total	62	1,402.05	194,325	26,385	7	82.74	2,625	400

Counties.	Apparatus of capture.												Total investment.
	Seines.		Gill nets.		Hand lines and trawl lines.		Pots.		Harpoons.		Dredges and rakes.		
	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.	
Providence	.....	.....	3	$30	.....	$110	.....	.....	2	$30	.....	$386	$18,855
Bristol	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	249	14,950
Newport	19	$12,100	.....	.....	.....	2,280	60	$120	28	420	.....	.....	205,655
Total	19	12,100	3	30	.....	2,390	60	120	30	450	.....	635	239,460

94.—Table showing by counties the yield of the vessel fisheries of Rhode Island in 1889.

Species.	Providence.		Bristol.		Newport.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Bluefish, fresh	.....	.....	.....	.....	5,500	$350	5,500	$350
Bluefish, salted	.....	.....	.....	.....	1,800	90	1,800	90
Cod, fresh	3,000	$90	.....	.....	213,940	6,448	216,940	6,538
Cod, salted	.....	.....	.....	.....	52,276	1,570	52,276	1,570
Haddock, fresh	.....	.....	.....	.....	98,120	2,207	98,120	2,207
Haddock, salted	.....	.....	.....	.....	10,640	212	10,640	212
Mackerel, fresh	8,000	700	.....	.....	18,612	1,821	26,612	2,581
Mackerel, salted	1,600	136	.....	.....	180,400	15,419	182,000	15,555
Menhaden, fresh	.....	.....	.....	.....	112,580,000	281,450	112,580,000	281,450
Swordfish, fresh	5,390	342	.....	.....	160,600	7,175	165,990	7,417
Lobsters	.....	.....	.....	.....	8,500	595	8,500	595
Clams (soft)	3,000	165	.....	.....	.....	.....	3,000	165
Quahogs	25,200	2,575	.....	.....	.....	.....	25,200	2,575
Scallops	2,700	300	.....	.....	.....	.....	2,700	300
Oysters	306,845	58,651	94,500	$18,054	.....	.....	401,345	76,705
Total	355,735	62,919	94,500	18,054	113,330,388	317,337	113,780,623	398,310

Certain average figures for the vessels in the three counties are presented in the following table. Newport County ranks first in the items of average tonnage, average value, average value of apparatus and outfit, average number of crew, and average

stock; Providence County excels in average value of catch per man, average value of catch per net ton, and average value of catch per each $100 invested in the vessel fishery; Bristol County leads in the single point of average value per ton.

95.—Table showing by counties certain average figures for the vessels employed in the fisheries of Rhode Island in 1889.

Counties.	Net tonnage.	Value per ton.	Value per vessel.	Value of apparatus and outfit.	No. of men to vessel.	Value of catch per man.	Value of catch per vessel.	Value of catch per each ton employed.	Value of catch per each $100 invested in fishing vessels.
Providence	10.54	$124	$1,308	$263	3	$1,850	$5,243	$497	$338
Bristol	9.95	161	1,600	269	2	858	2,257	227	120
Newport	28.48	139	3,948	876	8	1,030	7,556	265	156

The customs districts of Rhode Island correspond so closely with the counties that no discussion of the tables seems necessary. The statistics are given in the three following tables:

96.—Summary by customs districts of the vessel fisheries of Rhode Island in 1889.

Customs districts.	No. of vessels fishing.	Net tonnage.	Value of vessels.	Value of outfit, gear, provisions, fuel, etc.	Number and nationality of fishermen.			Value of catch.
					Americans.	All others.	Total.	
Newport	42	1,195.97	$165,825	$36,805	319	2	321	$317,337
Bristol and Warren	6	54.31	8,800	1,900	17	.....	17	6,012
Providence	14	151.77	19,700	3,405	38	.....	38	74,961
Total	62	1,402.05	194,325	42,110	374	2	376	398,310

Customs districts.	No. of vessels transporting.	Net tonnage.	Value of vessels.	Value of outfit, provisions, fuel, etc.	Number and nationality of crew.			Value of products transported.
					Americans.	All others.	Total.	
Newport	7	82.74	$2,625	$400	12	.....	12	$12,550
Bristol and Warren	.....	.....	.....	.....	.....	.....	.....	.....
Providence	.....	.....	.....	.....	.....	.....	.....	.....
Total	7	82.74	2,625	400	12	.....	12	12,550

97.—Table showing by species and customs districts the yield of the vessel fisheries of Rhode Island in 1889.

Species.	Newport.		Bristol and Warren.		Providence.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Bluefish, fresh	5,500	$350	.....	.....	.....	.....	5,500	$350
Bluefish, salted	1,800	90	.....	.....	.....	.....	1,800	90
Cod, fresh	213,940	6,448	.....	.....	3,000	$90	216,940	6,538
Cod, salted	52,276	1,570	.....	.....	.....	.....	52,276	1,570
Haddock, fresh	98,120	2,207	.....	.....	.....	.....	98,120	2,207
Haddock, salted	10,640	212	.....	.....	.....	.....	10,640	212
Mackerel, fresh	18,612	1,821	.....	.....	8,000	760	26,612	2,581
Mackerel, salted	180,400	15,419	.....	.....	1,660	136	182,000	15,555
Menhaden, fresh	112,580,000	281,450	.....	.....	.....	.....	112,580,000	281,450
Swordfish, fresh	160,600	7,175	.....	.....	5,390	242	165,990	7,417
Lobster, fresh	8,500	595	.....	.....	.....	.....	8,500	595
Clams (soft), fresh	.....	.....	.....	.....	3,000	165	3,000	165
Quahogs, fresh	.....	.....	.....	.....	25,200	2,575	25,200	2,575
Scallops, fresh	.....	.....	.....	.....	2,700	300	2,700	300
Oysters	.....	.....	31,500	$6,012	369,845	70,693	401,345	76,705
Total	113,330,388	317,337	31,500	6,012	418,735	74,961	113,780,623	398,310

98.—Table showing by customs districts the average tonnage, value, crew, and stock of vessels employed in the fisheries of Rhode Island in 1889.

Customs districts.	Average tonnage.		Average value.		Average value of outfit and apparatus.		Average number of crew.		Average gross stock.	
	Fishing.	Transporting.	Fishing.	Transporting.	Fishing.	Transporting.	Fishing.	Transporting.	Fishing.	Transporting.
Newport	28.48	10.82	$3,948	$375	$876	$56	8	2	$7,556	*$1,793
Bristol and Warren	9.05	.....	1,467	.....	317	.....	3	.....	1,002	.....
Providence	10.84	.....	1,407	.....	243	.....	3	.....	5,354	.....

* The value of products freighted.

The quantities of fish obtained with the different forms of apparatus, together with their value, are next presented in a single table. Seines, gill nets, and harpoons take only a single species each, while lines are employed in the capture of four species. Seines are more important than all the other forms combined and are credited with 112,580,000 pounds of menhaden, valued at $281,450; nets stocked only $83, on mackerel; harpoons took swordfish to the value of $7,417, and the catch with lines was valued at $29,020, being made up of mackerel, cod, haddock, and bluefish, the species ranking in the order given.

99.—Table showing by apparatus and species the yield of the vessel fisheries of Rhode Island in 1889, exclusive of the molluscan and crustacean fisheries.

Apparatus and species.	Pounds.	Value.	Apparatus and species.	Pounds.	Value.
Lines:			Seines:		
Bluefish, fresh	5,500	$350	Menhaden, fresh	112,580,000	$281,450
Bluefish, salted	1,800	90			
Cod, fresh	216,940	6,538	Gill nets:		
Cod, salted	52,276	1,570	Mackerel, fresh	920	83
Haddock, fresh	98,120	2,207			
Haddock, salted	10,640	212	Harpoons:		
Mackerel, fresh	25,692	2,498	Swordfish, fresh	165,990	7,417
Mackerel, salted	182,000	15,555			
			Grand total	113,339,878	317,970
Total	592,968	29,020			

More vessels of Rhode Island are engaged in the mackerel fishery than in any other branch. Although mackerel were scarce in 1889, the prevailing high price which the fish commanded was a strong incentive to undertake the pursuit of that species; 26 vessels, with a tonnage of 291.63, carrying 97 men, followed the fishery during the season, and took 208,612 pounds, for which $18,136 was received. The average stock per vessel was therefore $698, a sum considerably in excess of that obtained in the shore, swordfish, and lobster fisheries.

The shore fishery had a fleet of 21 vessels, with a tonnage of 249.81, and with crews aggregating 84 men. The catch, consisting of bluefish, cod, and haddock, amounted to 385,276 pounds, which was sold fresh and salted, the aggregate stock being $10,967, or an average of $522 per vessel.

The menhaden fleet consisted of 16 sail, the total tonnage of which was 890.05. The value of the menhaden vessels was $137,000, an average of $8,563. This figure is unusually large, and is due to the employment of steam vessels with a relatively high valuation per ton. The quantity of fish taken was 112,580,000 pounds, equivalent to 188,007,600 fish, having a value of $281,450. The average stock of the vessels was

$17,591. It is hardly necessary to remark that no other New England fishery, with the possible exception of the Pacific whale fishery carried on by vessels of New Bedford, now yields such large average returns. In 1880, when there were 61 Rhode Island vessels engaged in taking menhaden, the average catch was 1,126,128 pounds (against 7,036,250 pounds in 1889), and the average stock was only $2,815. There has been a gradual substitution of steam for sail vessels since 1880, with the striking improvement noted.

Sixteen vessels also engaged in the capture of swordfish; their tonnage was 232.43 and their complement of men 64. The result of the fishery was 165,990 pounds, for which the fishermen received $7,417, an average of $464 per vessel.

The fisheries for oysters, quahogs, soft clams, and scallops were followed by 17 vessels with a tonnage of 180.17, and with crews numbering 44 men. The oyster was the most valuable species taken, representing $76,705 out of the aggregate sum of $79,745 accruing from all molluscan fisheries. The large average stock in 1889, viz, $4,691, was due to the employment of steam vessels in taking oysters.

A single vessel of 5.45 tons, carrying 2 men, engaged in the lobster fishery in 1889, taking 8,500 pounds of that product, valued at $595. The vessel lobster fishery is much less important than that followed with small boats.

Two tables covering the vessel fisheries of Rhode Island, classified by fisheries, are presented.

100.—Table showing the number of vessels engaged in each fishery in Rhode Island in 1889, together with their tonnage, value, and number of crew.

Fisheries.	No. of vessels.	Net tonnage.	Value of vessels.	Number and nationality of crew.		
				Americans.	All others.	Total.
Shore	21	249.81	$21,200	82	2	84
Mackerel	26	291.63	22,325	95	2	97
Menhaden	16	890.05	137,000	219	.....	219
Swordfish	16	232.43	24,525	62	2	64
Crustacean	1	5.45	500	2	.....	2
Molluscan	17	180.17	26,350	44	.....	44

101.—Table showing by fisheries and species the yield of the vessel fisheries of Rhode Island in 1889.

Fisheries and species.	Pounds.	Value.	Fisheries and species.	Pounds.	Value.
Shore:			Menhaden:		
Bluefish, fresh	5,500	$350	Menhaden, fresh	112,540,000	$281,450
Bluefish, salted	1,800	90	Swordfish:		
Cod, fresh	216,940	6,538	Swordfish, fresh	165,990	7,417
Cod, salted	52,276	1,570	Crustacean:		
Haddock, fresh	98,120	2,207	Lobster	8,500	595
Haddock, salted	10,640	212			
Total	385,276	10,967	Molluscan:		
			Clams (soft)	3,000	165
Mackerel:			Quahogs	25,200	2,575
Mackerel, fresh	26,612	2,581	Scallops	2,700	300
Mackerel, salted	182,000	15,555	Oysters	401,345	76,705
Total	208,612	18,136	Total	432,245	79,745
			Grand total	113,789,623	396,310

98.—Table showing by customs districts the average tonnage, value, crew, and stock of vessels employed in the fisheries of Rhode Island in 1889.

Customs districts.	Average tonnage.		Average value.		Average value of outfit and apparatus.		Average number of crew.		Average gross stock.	
	Fishing.	Transporting.	Fishing.	Transporting.	Fishing.	Transporting.	Fishing.	Transporting.	Fishing.	Transporting.
Newport	28.48	10.82	$3,948	$375	$876	$56	8	2	$7,556	*$1,793
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Bluefish, salted	1,800	90			
Cod, fresh	216,940	6,538	Gill nets:		
Cod, salted	52,276	1,570	Mackerel, fresh	920	83
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Swordfish	16	232.43	24,525	62	2	64
Crustacean	1	5.45	500	2	.....	2
Molluscan	17	180.17	26,350	44	.....	44

101.—Table showing by fisheries and species the yield of the vessel fisheries of Rhode Island in 1889.

Fisheries and species.	Pounds.	Value.	Fisheries and species.	Pounds.	Value.
Shore:			Menhaden:		
Bluefish, fresh	5,500	$350	Menhaden, fresh	112,520,000	$281,450
Bluefish, salted	1,800	90	Swordfish:		
Cod, fresh	216,940	6,538	Swordfish, fresh	165,990	7,417
Cod, salted	52,276	1,570	Crustacean:		
Haddock, fresh	98,120	2,207	Lobster	8,500	595
Haddock, salted	10,640	212			
Total	385,276	10,967	Molluscan:		
			Clams (soft)	3,000	165
Mackerel:			Quahogs	25,200	2,575
Mackerel, fresh	26,612	2,581	Scallops	2,700	300
Mackerel, salted	182,000	15,555	Oysters	401,345	76,705
Total	208,612	18,136	Total	432,245	79,745
			Grand total	113,780,623	398,310

THE SHORE FISHERIES.

The shore fisheries of Rhode Island surpass the vessel fisheries in the items of persons employed and products, but represent less capital. They rank third in importance among the shore fisheries of New England, exceeding in value those of Connecticut and New Hampshire. The specially prominent feature of this branch is the pound-net and trap-net fishery, which reaches large proportions.

Shore fishing is prosecuted from every county in the State, but is most important in Newport County, in which 352 of the 896 shore fishermen are employed. Washington County has 205 fishermen, Kent County 146, Providence County 118, and Bristol 75. Newport County also leads in the amount of capital invested, the other counties being in about the above order.

In the item of products and value, Newport County takes higher rank than in persons engaged and capital invested. In 1889, the shore fisheries of the county were credited with yielding 8,605,559 pounds, valued at $199,249, while the catch for all counties was only 13,584,852 pounds, worth $536,834. The most important species in this county are scup, mackerel, bluefish, squeteague, and lobsters, in which the county ranks first. Providence County comes next with 787,120 pounds, valued at $128,215, of which 588,595 pounds, worth $112,599, represent oysters, in the output of which this county takes the first position. Washington County has a greater variety of water products than any county except Newport and yields a much larger quantity than Providence, although the value is considerably less; in 1889 3,116,200 pounds were taken, for which the fishermen received $75,951; the principal species in the county are alewives, butter-fish, eels, scup, flatfish, and flounders, in the catch of some of which the county leads all others. Bristol County, which has an unimportant net fishery, ranks second in the extent of its shore oyster fishery, which represents $73,111, while fish proper are worth only $965. The shore fisheries of Kent County are of less magnitude than those of the other counties, although the clam fishery is more important than elsewhere and the scallop fishery is followed only in this county.

The extent of the shore fisheries of each county is shown in the three tables which follow:

102.—Table showing by counties the number of persons engaged in the shore fisheries of Rhode Island in 1889.

Counties.	No.
Washington	205
Kent	146
Providence	118
Bristol	75
Newport	352
Total	896

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103.—Table showing by counties the apparatus employed in the shore fisheries of Rhode Island in 1889.

Designation.	Washington.		Kent.		Providence.		Bristol.		Newport.		Total.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Boats	135	$7,265	84	$9,960	111	$14,063	79	$8,955	242	$22,500	651	$62,743
Pound nets and trap nets	85	15,400	2	200	3	300	5	400	87	65,500	182	81,800
Fyke nets	126	1,630	150	450	.....	.....	.....	.....	100	800	376	2,680
Gill nets	5	410	33	2,780	3	200	.....	.....	73	4,210	114	7,600
Seines	27	1,500	2	150	3	200	.....	.....	.....	.....	32	1,850
Hand lines and trawl lines	.....	58	.....	60	.....	.....	.....	.....	.....	117	.....	235
Pots	920	1,150	275	133	1,000	250	.....	.....	2,950	4,850	5,145	6,383
Dredges	.....	.....	111	950	.....	.....	24	252	.....	.....	135	1,202
Tongs	1	5	14	76	183	900	168	832	.....	.....	366	1,813
Dip nets	.....	15	.....	.....	.....	.....	.....	.....	.....	.....	.....	15
Clamming apparatus	.....	24	.....	70	.....	20	.....	.....	.....	.....	.....	114
Total	.....	27,457	.....	14,829	.....	15,933	.....	10,439	.....	97,777	.....	166,435

104.—Table showing by counties and species the yield of the shore fisheries of Rhode Island in 1889.

Species.	Washington.		Kent.		Providence.		Bristol.		Newport.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives, fresh	79,450	$1,213	1,000	$20	.....	.....	.....	.....	419,000	$6,285	499,450	$7,518
Alewives, salted	412,000	8,240	.....	.....	.....	.....	.....	.....	.....	.....	412,000	8,240
Alewives, smoked	130,300	2,290	.....	.....	4,500	$90	.....	.....	.....	.....	134,800	2,380
Bluefish, fresh	38,950	2,532	14,500	1,015	1,500	150	.....	.....	346,425	22,951	401,375	26,648
Butter-fish, fresh	192,500	7,850	10,500	233	19,050	494	15,000	$450	30,000	800	267,050	9,827
Cod, fresh	.....	.....	.....	.....	.....	.....	.....	.....	85,000	2,490	85,000	2,490
Cod, salted	.....	.....	.....	.....	.....	.....	.....	.....	11,200	500	11,200	500
Eels, fresh	174,500	8,132	32,750	1,638	26,000	1,300	200	8	16,000	800	249,450	11,878
Flounders, fresh	210,000	4,873	67,500	1,585	7,250	155	.....	.....	245,000	5,812	529,750	12,425
Haddock, fresh	5,000	125	.....	.....	.....	.....	.....	.....	.....	.....	5,000	125
Kingfish, fresh	9,700	291	.....	.....	.....	.....	.....	.....	.....	.....	9,700	291
Mackerel, fresh	.....	.....	.....	.....	.....	.....	.....	.....	270,000	22,500	270,000	22,500
Mackerel, salted	.....	.....	.....	.....	.....	.....	.....	.....	120,000	9,000	120,000	9,000
Perch, fresh	16,000	640	.....	.....	.....	.....	.....	.....	.....	.....	16,000	640
Pollock, salted	.....	.....	.....	.....	.....	.....	.....	.....	51,520	1,840	51,520	1,840
Sea bass, fresh	14,100	484	18,650	688	1,000	40	200	6	459,200	12,605	493,150	13,823
Scup, fresh	622,600	9,610	6,000	180	.....	.....	200	6	5,435,000	82,125	6,063,800	91,921
Shad, fresh	11,850	789	1,300	125	1,500	135	2,000	100	.....	.....	16,650	1,149
Smelt, fresh	81,000	3,900	3,500	295	.....	.....	.....	.....	.....	.....	84,500	4,195
Squeteague, fresh	134,000	5,700	30,250	1,120	6,000	355	5,000	200	230,964	9,469	406,214	16,844
Striped bass, fresh	55,240	5,102	5,000	400	5,600	452	1,000	90	13,500	1,247	80,340	7,291
Tautog, fresh	116,500	4,340	11,000	520	6,125	320	3,000	90	51,000	2,430	187,625	7,700
Miscellaneous, fresh	10,500	210	.....	.....	.....	.....	.....	.....	35,750	715	46,250	925
Refuse fish, fresh	676,200	845	.....	.....	.....	.....	10,000	15	420,000	910	1,106,200	1,770
Lobsters	81,500	4,200	.....	.....	.....	.....	.....	.....	366,000	16,770	447,500	20,970
Crabs	4,460	1,125	.....	.....	.....	.....	.....	.....	.....	.....	4,460	1,125
Clams (soft)	37,750	3,010	193,000	19,300	100,000	10,000	.....	.....	.....	.....	330,750	32,310
Quahogs	.....	.....	192,000	20,900	20,000	2,125	.....	.....	.....	.....	212,000	23,025
Scallops	.....	.....	20,250	2,250	.....	.....	.....	.....	.....	.....	20,250	2,250
Oysters	2,100	450	44,100	9,074	588,595	112,599	388,073	73,111	.....	.....	1,022,868	195,234
Total	3,116,200	75,951	651,300	59,343	787,120	128,215	424,673	74,076	8,605,559	199,249	13,584,852	536,834

The relative importance of each of the various means of capture is illustrated in the next table, the specification being by counties and species. Of the apparatus employed in the capture of fish proper, pound nets and trap nets are by far the most effective devices, yielding 9,683,879 pounds, chiefly scup, alewives, and squeteague, worth $171,771. Lines took 759,720 pounds in 1889, principally mackerel, for which the fishermen got $46,758. Pots were the next most important apparatus if lobsters are included, taking 562,250 pounds, valued at $26,810. Gill nets stocked $18,841, seines $15,665, and fyke nets $3,045. Such miscellaneous apparatus as dredges, tongs, rakes, etc., produced 1,590,328 pounds of crabs, clams, oysters, scallops, etc., worth $253,944.

105.—Table showing by counties and apparatus the yield of the shore fisheries of Rhode Island in 1889.

Apparatus and species.	Washington.		Kent.		Providence.		Bristol.		Newport.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Seines:												
Alewives, fresh	4,450	$88	1,000	$20							5,450	$108
Alewives, salted	395,850	7,917									395,850	7,917
Alewives, smoked	58,000	1,250			4,500	$90					62,500	1,340
Bluefish, fresh			5,500	385							5,500	385
Butter-fish, fresh			1,000	20	6,550	244					7,550	264
Eels, fresh	39,400	2,009									39,400	2,009
Flounders, fresh					4,250	95					4,250	95
Perch, fresh	16,000	640									16,000	640
Sea bass, fresh					1,000	40					1,000	40
Shad, fresh	4,000	200	1,300	125	1,500	135					6,800	460
Smelt, fresh	13,500	675	3,500	295							17,000	970
Squeteague, fresh			500	30	4,000	235					4,500	265
Striped bass, fresh			5,000	400	5,600	452					10,600	852
Tautog, fresh					6,125	320					6,125	320
Total	531,200	12,779	17,800	1,275	33,525	1,611					582,525	15,665
Gill nets:												
Bluefish, fresh	10,000	650	9,000	630	1,500	150			245,150	$16,368	265,650	17,798
Butter-fish, fresh			1,500	53							1,500	53
Squeteague, fresh			24,750	990							24,750	990
Total	10,000	650	35,250	1,673	1,500	150			245,150	16,368	291,900	18,841
Pound and trap nets:												
Alewives, fresh	75,000	1,125							419,000	6,285	494,000	7,410
Alewives, salted	16,150	323									16,150	323
Alewives, smoked	72,300	1,040									72,300	1,040
Bluefish, fresh	23,950	1,582							47,925	3,163	71,875	4,745
Butter-fish, fresh	192,500	7,850	8,000	160	12,500	250	15,000	$450	30,000	800	258,000	9,510
Eels, fresh	95,100	4,021					200	8			95,300	4,029
Flounders, fresh	180,750	4,078	2,000	40	3,000	60			210,000	4,762	395,750	8,940
Kingfish, fresh	9,700	291									9,700	291
Scup, fresh	622,600	9,610	6,000	180			200	6	5,435,000	82,125	6,063,800	91,921
Sea bass, fresh	14,100	484					200	6	459,200	12,605	473,500	13,095
Shad, fresh	7,850	589					2,000	100			9,850	689
Smelt, fresh	67,500	3,225									67,500	3,225
Striped bass, fresh	55,240	5,102					1,000	90	13,500	1,247	69,740	6,439
Squeteague, fresh	134,000	5,700	5,000	100	2,000	120	5,000	200	230,964	9,469	376,964	15,589
Tautog, fresh	48,000	1,560					3,000	90	6,000	180	57,000	1,830
Refuse fish, fresh	676,200	845					10,000	15	420,000	910	1,106,200	1,770
Miscellaneous fish, fresh	10,500	210							35,750	715	46,250	925
Total	2,301,440	47,635	21,000	480	17,500	430	36,600	965	7,307,339	122,261	9,683,879	171,771
Hand and trawl lines:												
Bluefish, fresh	5,000	300							53,350	3,420	58,350	3,720
Cod, fresh									85,000	2,490	85,000	2,490
Cod, salted									11,200	500	11,200	500
Flounders, fresh			15,500	345							15,500	345
Haddock, fresh	5,000	125									5,000	125
Mackerel, fresh									270,000	22,500	270,000	22,500
Mackerel, salted									120,000	9,000	120,000	9,000
Pollock, salted									51,520	1,840	51,520	1,840
Sea bass, fresh			18,650	688							18,650	688
Tautog, fresh	68,500	2,780	11,000	520					45,000	2,250	124,500	5,550
Total	78,500	3,205	45,150	1,553					636,070	42,000	759,720	46,758
Fyke nets:												
Flounders, fresh	29,250	795	50,000	1,200					35,000	1,050	114,250	3,045
Pots:												
Eels, fresh	40,000	2,102	32,750	1,638	26,000	1,300			16,000	800	114,750	5,840
Lobsters, fresh	81,500	4,200							366,000	16,770	447,500	20,970
Total	121,500	6,302	32,750	1,638	26,000	1,300			382,000	17,570	562,250	26,810
Miscellaneous:												
Crabs	4,460	1,125									4,460	1,125
Clams (soft)	37,750	3,010	193,000	19,300	100,000	10,000					330,750	32,310
Quahogs			192,000	20,900	20,000	2,125					212,000	23,025
Scallops			20,250	2,250							20,250	2,250
Oysters	2,100	450	44,100	9,074	588,595	112,599	388,073	73,111			1,022,868	195,234
Total	44,310	4,585	449,350	51,524	708,595	124,724	388,073	73,111			1,590,328	253,944
Grand total	3,116,200	75,951	651,300	59,343	787,120	128,215	424,673	74,076	8,605,559	199,249	13,584,852	536,834

The following table, based on the preceding, illustrates the relative quantity and value of the products taken in the various kinds of apparatus used in the shore fisheries. It is of interest to observe the great difference which exists between the percentage of quantity and value in some forms of apparatus. Although pound nets and trap nets yield over 71 per cent of the shore products, the value of the catch is only 32 per cent, while dredges, tongs, etc., secure only 11 per cent of the quantity but 47 per cent of the value.

106.—Table showing the relative quantity and value of yield in each principal form of apparatus of capture employed in the shore fisheries of Rhode Island in 1889.

Apparatus.	Percentage.	
	Quantity.	Value.
Seines	4.29	2.91
Gill nets	2.15	3.51
Pound nets and trap nets	71.28	32.00
Fyke nets	.84	.56
Hand lines and trawl lines	5.59	8.73
Pots	4.14	4.99
Miscellaneous	11.71	47.30
Total	100.00	100.00

Certain averages and percentages for each county are given in the next tables. Providence County ranks first in the average value of catch per man and also in the average value of catch per each $100 invested in apparatus, Bristol County being second in both these items. Washington County has the first position in the average value of catch per each $100 invested in boats, followed by Providence County.

The relative value of the catch in each form of apparatus in each county is shown. Pound nets and trap nets yield 63 per cent and 61 per cent, respectively, of the stock from the shore fisheries in Washington and Newport counties, and only 1 per cent each in Kent and Bristol counties; while dredges, tongs, etc., take 87 per cent, 97 per cent, and 99 per cent, respectively, of the value of the products in Kent, Providence, and Bristol counties, and only 6 per cent in Washington county.

The final table exhibits, for each county, the proportional value of each species to the value of the total yield.

107.—Table showing by counties certain averages and percentages of the shore fisheries of Rhode Island in 1889.

Counties.	Value of catch per each $100 invested in boats.	Value of catch per each $100 invested in apparatus.	Value of catch per each man employed.	Percentage of value of yield in principal forms of apparatus.							
				Total.	Pound nets and trap nets.	Seines.	Gill nets.	Fyke nets.	Lines.	Pots.	Miscellaneous.
Washington	$1,045	$374	$370	100.00	62.72	16.81	.86	1.05	4.22	8.30	6.04
Kent	596	1,211	406	100.00	.81	2.15	2.82	2.02	2.62	2.76	86.82
Providence	912	6,748	1,087	100.00	.33	1.26	.12	.....	.....	1.01	97.28
Bristol	827	4,938	988	100.00	1.30	.....	.....	.....	.....	.....	98.70
Newport	886	265	566	100.00	61.36	.....	8.21	.53	21.08	8.82	.....

108.—Table showing by counties the percentage of the value of each species to the total yield of the shore fisheries of Rhode Island in 1889.

Species.	Washington.	Kent.	Providence.	Bristol.	Newport.
Alewives, fresh	1.60	.03			3.15
Alewives, salted	10.85				
Alewives, smoked	3.03		.07		
Bluefish, fresh	3.33	1.71	.12		11.52
Butter-fish, fresh	10.34	.39	.38	.61	.40
Cod, fresh					1.25
Cod, salted					.25
Eels, fresh	10.71	2.76	1.01	.01	.40
Flatfish and flounders, fresh	6.42	2.67	.12		2.92
Haddock, fresh	.16				
Kingfish, fresh	.38				
Mackerel, fresh					11.29
Mackerel, salted					4.52
Perch or cunners, fresh	.84				
Pollock, salted					.92
Sea bass, fresh	.64	1.16	.03	.01	6.32
Scup, fresh	12.65	.30		.01	41.22
Shad, fresh	1.04	.21	.11	.13	
Smelt, fresh	5.13	.50			
Squeteague, fresh	7.50	1.89	.28	.27	4.75
Striped bass, fresh	6.72	.68	.35	.12	.63
Tautog, fresh	5.71	.88	.25	.12	1.22
Miscellaneous fish, fresh	.28				.36
Refuse fish, fresh	1.11			.02	.46
Lobsters	5.53				8.42
Crabs	1.48				
Clams (soft)	3.96	32.52	7.80		
Quahogs		35.22	1.66		
Scallops		3.79			
Oysters	.59	15.29	87.82	98.70	
Total	100.00	100.00	100.00	100.00	100.00

THE MENHADEN INDUSTRY.

In the following table the extent of the menhaden business, viewed as a shore industry, is exhibited. Rhode Island is now more interested in this branch than any other New England State, and the industry ranks among the most prominent enterprises of the State. The capital invested in 1889 was $452,925; 573 persons were employed, and 177,133,333 fish were handled, for which $265,700 was paid. The manufactured products, consisting of different grades of oil and various kinds of fertilizers, were worth $427,757, an increase of $217,208 over 1887 and $93,070 over 1888.

109.—Table showing the extent of the menhaden industry of Rhode Island.

Designation.	1889.
Number of factories in operation	4
Value of factories	$208,000
Amount of cash capital	$76,000
Number of shoresmen employed	358
Number of fishermen employed	215
Number of steam vessels employed	11
Net tonnage	758.45
Value	$133,000
Value of outfit	$27,000
Number of sailing vessels employed in fishing	4
Net tonnage	104.10
Value	$3,000
Value of outfit	$3,400
Number of sailing vessels employed as "carryaways"	3
Net tonnage	42.83
Value	$2,325
Value of outfit	$200
Number of menhaden handled	177,133,333
Value to fishermen	$265,700
Number of gallons of oil made	1,782,145
Value as sold	$320,743
Number of tons of scrap produced	7,397
Value as sold	$107,014

VI.—THE FISHERIES OF CONNECTICUT.

GENERAL REMARKS AND STATISTICS.

The fisheries of Connecticut rank next in general importance to those of Maine. Some special branches are of greater extent than elsewhere in New England, and others are of minor consequence compared with neighboring States. The general fisheries for food-fish are of less importance than in Rhode Island, but the taking of oysters reaches greater proportions than elsewhere in this region, and in the extent of its menhaden industry Connecticut ranks second. This State is the only one, in addition to Massachusetts, which now prosecutes mammal fisheries of commercial importance.

The river fisheries were investigated to the limits of tidewater except in the case of the Connecticut, which was canvassed for 10 miles above its mouth to Essex.

Condensed statistics for this State, covering the three points of persons employed, apparatus and capital, and products, are given in the following tables:

110.—Table of persons employed.

How engaged.	No.
On fishing vessels	1,030
On transporting vessels	32
In shore fisheries	1,252
On shore, in factories, fish-houses, etc	733
Total	3,047

111.—Table of apparatus and capital.

Designation.	No.	Value.
Vessels fishing (tonnage 5,052.60)	200	$512,155
Outfit		134,652
Vessels transporting (tonnage 217.08)	14	13,395
Outfit		2,050
Boats	1,353	98,595
Apparatus of capture—vessel fisheries:		
Seines	12	5,020
Lines	745	995
Pots	1,785	5,240
Harpoons	22	264
Dredges, etc		23,150
Apparatus of capture—shore fisheries:		
Haul seines	43	2,730
Pound nets	113	37,800
Gill nets	62	2,524
Fyke nets	440	2,230
Lines		280
Pots	9,771	19,719
Spears	215	205
Dredges, rakes, etc		6,525
Shore property		1,647,105
Cash capital		312,200
Total		2,826,834

112.—Table of products.

Species.	Vessel fisheries.		Shore fisheries.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives, fresh			53,272	$670	53,272	$670
Bluefish, fresh	453,326	$22,970	63,630	4,413	516,956	27,383
Butter-fish, fresh			42,400	1,064	42,400	1,064
Cod, fresh	1,523,418	49,696	6,445	322	1,529,863	50,018
Cunners, fresh			5,000	200	5,000	200
Eels, fresh			315,150	24,930	315,150	24,930
Flatfish and flounders, fresh	7,780	177	626,200	12,828	633,980	13,005
Frostfish or tomcod, fresh			123,500	4,875	123,500	4,875
Haddock, fresh	199,290	5,309	6,300	290	205,590	5,599
Hake, fresh	900	15			900	15
Halibut, fresh	264,890	20,293			264,890	20,293
Mackerel, fresh	26,170	2,331	7,330	980	33,500	3,311
Mackerel, salted	16,100	1,539			16,100	1,539
Menhaden, fresh	41,338,834	86,812	6,652,880	13,757	47,991,714	100,569
Pollock, fresh	17,400	365			17,400	365
Red snappers, fresh	520,000	16,800			520,000	16,800
Salmon, fresh			280	222	280	222
Sea bass, fresh	209,245	13,595	40,956	3,046	250,201	16,641
Scup, fresh			6,800	170	6,800	170
Shad, fresh			195,852	16,580	195,852	16,580
Smelt, fresh			12,800	1,042	12,800	1,042
Squeteague, fresh	2,165	105	204,480	8,193	206,645	8,298
Striped bass			38,770	3,430	38,770	3,430
Swordfish, fresh	146,190	8,285			146,190	8,285
Tautog, fresh	21,340	947	217,300	10,405	238,640	11,352
Whiting, fresh			11,640	174	11,640	174
Miscellaneous fish, fresh			306,860	1,859	306,860	1,859
Lobsters	446,890	26,064	1,054,400	57,035	1,501,290	83,099
Crabs			8,300	300	8,300	300
Terrapin			3,057	1,280	3,057	1,280
Clams (soft)			263,600	24,900	[a] 263,600	24,900
Quahogs	3,600	400	167,296	20,714	[b] 170,896	21,114
Scallops			2,700	230	[c] 2,700	230
Oysters	8,332,765	830,700	2,068,262	225,107	[d] 10,401,027	1,055,807
Oyster shells [e]			7,800,000	6,500	[f] 7,800,000	6,500
Algæ			18,660,000	4,903	18,660,000	4,903
Seal and other skins		8,610				[g] 8,610
Whale oil	176,701	12,074			[h] 176,701	12,074
Total	53,707,004	1,107,087	38,965,460	450,419	92,672,464	1,557,506

[a] 26,360 bushels. [b] 21,362 bushels. [c] 772 bushels. [d] 1,485,861 bushels.

[e] In addition to the figures given for shells in the above table, which represent only the output of the shell beds in the Housatonic River, 41,290,000 pounds, valued at $33,032, were also handled, their value being included with that of the oysters when the latter were first disposed of.

[f] 130,000 bushels. [g] The value of 1,326 seal and other skins. [h] 23,560 gallons.

THE VESSEL FISHERIES.

The fishing fleet of Connecticut is next in size to the fleets of Massachusetts and Maine, and is noteworthy for a larger number of steam vessels than is found elsewhere in the fisheries of the United States. The vessel fisheries of Connecticut of special importance are those for bluefish, cod, halibut, red snapper, menhaden, lobsters, and oysters, the last named being the most extensive fishery in the State. The red-snapper fishery is prosecuted off the coast of Florida. Detailed tables exhibiting almost every phase of the vessel fisheries are presented.

There are three counties in Connecticut from which vessel fisheries are carried on, viz, New London, New Haven, and Fairfield, each of which has fisheries of considerable prominence.

The first table of the county series shows 1,062 persons employed on vessels, of whom 557 belong in New London County, 273 in New Haven County, and 232 in Fairfield County. Of the different nationalities represented by the fishermen the United States greatly predominates, with 916 men, or 86.2 per cent, after which come Portugal with 52 men or 4.9 per cent; Sweden and Norway, with 61 men or 5.8 per cent; British Provinces with 26 men or 2.4 per cent, and other countries with 7 men or 0.7 per cent.

The next table shows 200 fishing vessels and 14 transporting vessels engaged in the fisheries of Connecticut in 1889. These, with their outfit and apparatus, were valued at $696,921.

The fishing vessels of New London County, 86 in number, use chiefly seines, lines, and pots; in New Haven and Fairfield counties dredges are the principal form of apparatus.

The vessel fisheries of the State yielded 53,707,004 pounds of products, valued, at first hands, at $1,107,087. New London County is credited with the largest quantity of products, and Fairfield County with the smallest catch, although the output of the fisheries of New Haven County is of greater value than that of the two other counties combined, owing to the relatively high price of oysters, which are practically the only products of the county, constituting 99 per cent of the yield in this as in Fairfield County.

113.—Table showing by counties the number and nationality of persons engaged in the vessel fisheries of Connecticut in 1889.

Counties.	Number and nationality of men on fishing vessels.							Number and nationality of men on transporting vessels.		
	Americans.	Portuguese.	Swedes.	Norwegians.	British provincials.	All others.	Total.	Americans.	Swedes.	Total.
New London	444	42	33	6	12	4	541	15	1	16
New Haven	235	5	9	.....	8	.....	257	16	.....	16
Fairfield	206	5	12	.....	6	3	232	.....	.....	.....
Total	885	52	54	6	26	7	1,030	31	1	32

114.—Table showing by counties the number, value, and net tonnage of vessels and the quantity and value of apparatus of capture employed in the vessel fisheries of Connecticut in 1889.

Counties.	Vessels.							
	Fishing.				Transporting.			
	No.	Net tonnage.	Value.	Value of outfit.	No.	Net tonnage.	Value.	Value of outfit.
New London	86	2,485.96	$152,805	$81,050	7	128.58	$6,560	$1,050
New Haven	41	1,302.97	200,850	26,080	7	88.50	6,835	1,000
Fairfield	73	1,263.67	158,500	27,522	.....	.....	.....	.....
Total	200	5,052.60	512,155	134,652	14	217.08	13,395	2,050

Counties.	Apparatus of capture.										Total investment.
	Seines.		Lines.		Pots.		Harpoons.		Dredges, etc.		
	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.	
New London	10	$4,070	.....	$990	1,785	$5,240	20	$240	.....	.....	$252,005
New Haven	2	950	.....	.....	.....	.....	.....	.....	.....	$14,470	250,185
Fairfield	.....	.....	.....	5	.....	.....	2	24	.....	8,680	194,731
Total	12	5,020	.....	995	1,785	5,240	22	264	.....	23,150	696,921

115.—Table showing by counties the yield of the vessel fisheries of Connecticut in 1889.

Species.	New London.		New Haven.		Fairfield.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Bluefish, fresh	453,326	$22,970					453,326	$22,970
Cod, fresh	1,523,418	49,696					1,523,418	49,696
Flounders, fresh	7,780	177					7,780	177
Haddock, fresh	199,290	5,309					199,290	5,309
Hake, fresh	900	15					900	15
Halibut, fresh	264,890	20,293					264,890	20,293
Mackerel, fresh	24,370	2,175			1,800	$156	26,170	2,331
Mackerel, salted	16,100	1,539					16,100	1,539
Menhaden, fresh	39,138,834	82,412	2,200,000	$4,400			41,338,834	86,812
Pollock, fresh	17,400	365					17,400	365
Red snapper, fresh	520,000	16,800					520,000	16,800
Sea bass, fresh	209,245	13,595					209,245	13,595
Squeteague, fresh	2,165	105					2,165	105
Swordfish, fresh	135,452	7,905			10,738	380	146,190	8,285
Tautog, fresh	21,340	947					21,340	947
Lobsters	446,890	26,064					446,890	26,064
Quahogs	3,600	400					3,600	400
Oysters			6,201,657	582,925	2,131,108	247,775	8,332,765	830,700
Seal and other skins		*8,610						8,610
Whale oil	176,701	12,074					176,701	12,074
Total	43,161,701	271,451	8,401,657	587,325	2,143,646	248,311	53,707,004	1,107,087

*1,326 skins.

The superiority of the vessels in New Haven County is brought out in the following table giving certain average figures for the vessel fisheries of Connecticut:

116.—Table showing by counties certain average figures for the vessels employed in the fisheries of Connecticut in 1889.

Counties.	Net tonnage.	Value per ton.	Value per vessel.	Value of apparatus and outfit.	No. of men to vessel.	Value of catch per man.	Value of catch per vessel.	Value of catch per each ton employed.	Value of catch per each $100 invested in fishing vessels.
New London	29.18	$62	$1,807	$1,086	6	$537	$3,231	$110	$112
New Haven	31.78	154	4,899	1,012	6	2,285	14,325	451	242
Fairfield	17.31	125	2,171	496	3	1,070	3,401	196	127

The statistics of vessel fisheries of Connecticut are next considered by customs districts, the vessels being credited to the districts in which their fishing licenses are obtained. Vessels are enrolled for the fisheries in four districts, the extent of the industry in each of which is shown in the two following tables. A table giving certain averages for each district is also presented.

117.—Summary by customs districts of the vessel fisheries of Connecticut in 1889.

Customs districts.	No. of vessels fishing.	Net tonnage.	Value of vessels.	Value of outfit, gear, provisions, fuel, etc.	Number and nationality of fishermen.							Value of catch.
					Americans.	Portuguese.	Swedes.	Norwegians.	British provincials.	All others.	Total.	
Stonington	47	1,302.39	$96,165	$50,480	240	5	10	2	2	2	261	$139,399
New London	39	1,183.57	56,640	41,110	204	37	23	4	10	2	280	132,052
New Haven	41	1,302.97	200,850	41,500	235	5	9	.....	8	.....	257	587,325
Fairfield	73	1,263.67	158,500	36,231	206	5	12	.....	6	3	232	248,311
Total	200	5,052.60	512,155	169,321	885	52	54	6	26	7	1,030	1,107,087

Customs districts.	No. of vessels transporting.	Net tonnage.	Value of vessels.	Value of outfit, provisions, fuel, etc.	Number and nationality of crew.							Value of products transported.
					Americans.	Portuguese.	Swedes.	Norwegians.	British provincials.	All others.	Total	
Stonington	5	92.83	$5,160	$800	11	.....	1	.....	.....	.....	12	$11,301
New London	2	35.75	1,400	250	4	.....	.....	.....	.....	.....	4	10,800
New Haven	7	88.50	6,835	1,000	16	.....	.....	.....	.....	.....	16	14,528
Fairfield	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total	14	217.08	13,395	2,050	31	.....	1	.....	.....	.....	32	36,629

118.—Table showing by species and customs districts the yield of the vessel fisheries of Connecticut in 1889.

Species.	Stonington.		New London.		New Haven.		Fairfield.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Bluefish, fresh	99,500	$4,885	353,826	$18,085	.....	.....	.....	.....	453,326	$22,970
Cod, fresh	769,700	25,928	753,718	23,768	.....	.....	.....	.....	1,523,418	49,696
Flatfish and flounders, fresh	2,000	50	5,780	127	.....	.....	.....	.....	7,780	177
Haddock, fresh	81,500	2,294	117,790	3,015	.....	.....	.....	.....	199,290	5,309
Hake, fresh	900	15	.....	.....	.....	.....	.....	.....	900	15
Halibut, fresh	125,890	9,373	139,000	10,920	.....	.....	.....	.....	264,890	20,293
Mackerel, fresh	3,050	320	21,320	1,855	.....	.....	1,800	$156	26,170	2,331
Mackerel, salted	16,100	1,539	.....	.....	.....	.....	.....	.....	16,100	1,539
Menhaden, fresh	20,300,137	42,731	18,838,697	39,681	2,200,000	$4,400	.....	.....	41,338,834	86,812
Pollock, fresh	9,400	185	8,000	180	.....	.....	.....	.....	17,400	365
Red snapper, fresh	445,000	14,000	75,000	2,800	.....	.....	.....	.....	520,000	16,800
Sea bass, fresh	112,600	7,776	96,645	5,819	.....	.....	.....	.....	209,245	13,595
Squeteague, fresh	.....	.....	2,165	105	.....	.....	.....	.....	2,165	105
Swordfish, fresh	34,156	1,854	101,296	6,051	.....	.....	10,738	380	146,190	8,285
Tautog, fresh	11,440	510	9,900	437	.....	.....	.....	.....	21,340	947
Lobsters	350,350	20,288	96,540	5,776	.....	.....	.....	.....	446,890	26,064
Quahogs	.....	.....	3,600	400	.....	.....	.....	.....	3,600	400
Oysters	.....	.....	.....	.....	6,201,657	582,925	2,131,108	247,775	8,332,765	830,700
Seal and other skins	.....	.....	.....	8,610	.....	.....	.....	.....	.....	8,610
Whale oil	91,651	7,651	85,050	4,423	.....	.....	.....	.....	176,701	12,074
Total	22,453,374	139,399	20,708,327	132,052	8,401,657	587,325	2,143,646	248,311	53,707,004	1,107,087

119.—Table showing by customs districts the average tonnage, value, crew, and stock of vessels employed in the fisheries of Connecticut in 1889.

Customs districts.	Average tonnage.		Average value.		Average value of outfit and apparatus.		Average number of crew.		Average gross stock.	
	Fishing.	Transporting.	Fishing.	Transporting.	Fishing.	Transporting.	Fishing.	Transporting.	Fishing.	Transporting.*
Stonington	27.71	18.57	$2,046	$1,032	$1,074	$160	6	2	$2,966	$2,260
New London	30.35	17.88	1,452	700	1,054	125	6	2	3,589	5,400
New Haven	31.78	12.64	4,899	976	1,012	143	6	2	14,325	2,075
Fairfield	17.31	.....	2,171	.....	496	.....	3	.....	3,401	.....

* The value of products transported.

The quantity and value of fish taken in each form of apparatus are shown in the next tabulation. Lines yield the largest money returns, but seines secure the greatest quantities of fish.

120.—Table showing by apparatus and species the yield of the vessel fisheries of Connecticut in 1889, exclusive of the molluscan, crustacean, and mammalian fisheries.

Apparatus and species.	Pounds.	Value.	Apparatus and species.	Pounds.	Value.
Seines:			Lines—continued.		
Mackerel, salted	13,800	$1,239	Mackerel, salted	2,300	$300
Menhaden, fresh	41,338,834	86,812	Pollock, fresh	17,400	365
			Red snapper, fresh	520,000	16,800
Total	41,352,634	88,051	Sea bass, fresh	209,245	13,595
			Squeteague, fresh	2,165	105
Lines:			Tautog, fresh	21,340	947
Bluefish, fresh	453,326	22,970			
Cod, fresh	1,523,418	49,696	Total	3,248,224	132,903
Flatfish and flounders, fresh	7,780	177			
Haddock, fresh	199,290	5,309	Harpoons:		
Hake, fresh	900	15	Swordfish, fresh	146,190	8,285
Halibut, fresh	264,890	20,293			
Mackerel, fresh	26,170	2,331	Grand total	44,747,048	229,239

From Table 121, giving the full extent of each fishery in which the vessels of Connecticut engaged, it will be seen that mollusks, of which the oyster was chief, were the objects of capture by more vessels than any other product; 113 vessels were so employed. The shore fishery was followed by 37 vessels, the lobster fishery by 22 vessels, and the market fishery for cod, haddock, bluefish, sea bass, etc., by 27 vessels. The other fisheries had from 4 to 11 vessels each. As previously explained in discussing similar tables, the object of such a presentation is to exhibit the greatest number of vessels engaged in each fishery during any portion of the year, together with their tonnage, value, and crew, all of which items are duplicated to the extent to which each vessel follows two or more fisheries. The catch, however, is not duplicated, and represents simply the results obtained in each fishery.

The market fishery, according to Table 122, yields a larger stock than any other fishery except the oyster, the 27 vessels therein employed taking products to the value of $104,072, an average of $3,855 per vessel. The menhaden fishery comes next, with $86,812, or $14,469 per vessel. The vessels in the shore fishery stocked $26,360, or $713 each; while $26,064 resulted from the lobster fishery, the vessels earning $1,185 each. The 113 vessels composing the oyster and clam fleet took products to the value of $831,100, averaging $7,355.

121.—Table showing the number of vessels engaged in each fishery in Connecticut in 1889, together with their tonnage, value, and number of crew.

Fisheries.	No. of vessels.	Net tonnage.	Value of vessels.	Number and nationality of crew.						
				Americans.	British provincials.	Portuguese.	Swedes.	Norwegians.	Others.	Total.
Market	27	1,022.44	$62,600	138	5	23	26	2	3	197
Shore	37	481.84	31,330	104	.....	2	3	.....	2	111
Mackerel	9	160.40	11,650	26	7	1	.....	3	.....	37
Menhaden	6	451.80	61,500	124	1	.....	.....	.....	.....	125
Swordfish	11	186.86	13,150	35	.....	3	.....	.....	1	39
Crustacean	22	261.18	18,915	59	.....	.....	3	.....	.....	62
Molluscan	113	2,326.89	319,150	372	13	10	21	.....	3	419
Whale and seal	4	402.33	15,000	45	6	16	1	.....	1	69

122.—Table showing by fisheries and species the yield of the vessel fisheries of Connecticut in 1889.

Fisheries and species.	Pounds.	Value.	Fisheries and species.	Pounds.	Value.
Market:			Mackerel:		
Bluefish, fresh	436,396	$21,603	Mackerel, fresh	26,170	$2,331
Cod, fresh	1,267,000	41,129	Mackerel, salted	16,100	1,539
Haddock, fresh	140,500	3,719	Swordfish, fresh	456	24
Hake, fresh	900	15			
Halibut, fresh	264,750	20,281	Total	42,726	3,894
Pollock, fresh	17,400	365			
Red snapper, fresh	520,000	16,800	Menhaden, fresh	41,338,834	86,812
Swordfish, fresh	2,550	160	Swordfish, fresh	143,184	8,101
			Lobster	446,890	26,064
Total	2,649,496	104,072	Molluscan:		
Shore:			Oysters	8,332,765	830,700
Bluefish, fresh	16 930	1,367	Quahogs	3,600	400
Cod, fresh	256,418	8,567			
Flatfish and flounders, fresh	7,780	177	Total	8,336,365	831,100
Haddock, fresh	58,790	1,590	Whale and seal:		
Halibut, fresh	140	12	Seal and other skins	.....	8,610
Sea bass, fresh	209,245	13,595	Whale oil	176,701	12,074
Squeteague, fresh	2,165	105			
Tautog, fresh	21,340	947	Total	176,701	20,684
Total	572,808	26,360	Grand total	53,707,004	1,107,087

THE SHORE FISHERIES.

The shore fisheries of Connecticut, as gauged by the value of the products, are, as a whole, of less importance than those of Rhode Island, although special branches are of greater extent, among which the shad, oyster, and lobster fisheries may be mentioned. The statistics show the fisheries by counties and by apparatus.

There are four counties in Connecticut from which shore fishing is carried on; these are New London, Middlesex, New Haven, and Fairfield, each of which excels in certain features or branches, as brought out in the following series of tables.

Of 1,252 shore fishermen in the State, 546 were employed in Fairfield County, 277 in New Haven County, 247 in New London County, and 182 in Middlesex County.

New London County had the largest investment in the shore fisheries, viz, $51,926, closely followed by Fairfield County with $50,129; New Haven and Middlesex counties had, respectively, $35,542 and $33,011. Boats represent more than half the aggregate value of the property in the shore fisheries, and pound nets constitute the most important and valuable form of apparatus.

The shore fisheries yielded 38,965,460 pounds, which were sold for $450,419. Fairfield County took 12,250,056 pounds, valued at $174,685, of which 7,800,000 pounds represented oyster shells obtained from the Housatonic River and used by oyster-planters in preparing beds. The oysters secured amounted to 1,063,769 pounds (or 151,967 bushels), for which $121,122 was received. The next most important product was the quahog or round clam, of which 124,480 pounds (or 15,560 bushels), valued at $15,710, were marketed. The output of soft clams was also considerable, having a value of $6,990. The molluscan fisheries of this county are thus seen to be the most extensive. New Haven County ranks second in quantity and value of products, taking 9,830,186 pounds, worth $133,303. Oysters and clams are also the most important species in this county, $104,680 accruing from their sale. The catch of menhaden is the only other noteworthy feature of the shore fisheries of the county; 6,306,486 pounds of this species, with a value of $13,010, were taken. New London County is credited with 9,381,109 pounds, worth $95,740. In this county shellfish form an inconspicuous part of the product, the output being less than in any other county; the yield of

lobsters is greater than in all the other counties combined, being 887,700 pounds, valued at $45,355. The bulk of the catch consists of algæ. Middlesex County takes the largest quantities of eels and shad. The entire output of the county was 7,504,109 pounds, for which the fishermen received $46,691; of this quantity 6,500,000 pounds were algæ.

123.—Table showing by counties the number of persons engaged in the shore fisheries of Connecticut in 1889.

Counties.	No.
New London	247
Middlesex	182
New Haven	277
Fairfield	546
Total	1,252

124.—Table showing by counties the apparatus employed in the shore fisheries of Connecticut in 1889.

Designation.	New London.		Middlesex.		New Haven.		Fairfield.		Total.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Boats	259	$21,235	174	$8,015	272	$23,280	648	$46,065	1,353	$98,595
Seines	8	400	2	100	3	120	30	2,110	43	2,730
Pound nets	51	10,700	36	17,400	26	9,700	.....	.....	113	37,800
Gill nets	20	150	22	1,760	10	154	10	460	62	2,524
Fyke nets	364	1,790	21	105	17	85	38	250	440	2,230
Lines	.....	110	.....	20	.....	60	.....	90	.....	280
Pots	5,182	14,361	2,734	2,886	1,169	1,578	686	894	9,771	19,719
Spears	.....	110	.....	60	.....	15	.....	20	.....	205
Dredges, rakes, etc	.....	3,070	.....	2,665	.....	550	.....	240	.....	6,525
Total	.....	51,926	.....	33,011	.....	35,542	.....	50,129	.....	170,608

125.—Table showing by counties and species the yield of the shore fisheries of Connecticut in 1889.

Species.	New London.		Middlesex.		New Haven.		Fairfield.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives, fresh	3,280	$165	41,392	$280	8,600	$225	.....	.....	53,272	$670
Bluefish, fresh	32,520	1,823	.....	.....	12,300	950	18,810	$1,640	63,630	4,413
Butter-fish, fresh	35,000	914	.....	.....	7,400	150	.....	.....	42,400	1,064
Cod, fresh	6,445	322	.....	.....	.....	.....	.....	.....	6,445	322
Cunners, fresh	.....	.....	5,000	200	.....	.....	.....	.....	5,000	200
Eels, fresh	139,900	8,295	116,750	10,080	15,500	1,340	43,000	5,215	315,150	24,930
Flatfish and flounders, fresh	526,000	10,363	8,200	170	4,500	100	87,500	2,195	626,200	12,828
Frostfish or tomcod, fresh	21,600	500	.....	.....	.....	.....	101,900	4,375	123,500	4,875
Haddock, fresh	6,300	290	.....	.....	.....	.....	.....	.....	6,300	290
Mackerel, fresh	7,330	980	.....	.....	.....	.....	.....	.....	7,330	980
Menhaden, fresh	19,167	89	327,227	658	6,306,486	13,010	.....	.....	6,652,880	13,757
Salmon, fresh	.....	.....	260	204	20	18	.....	.....	280	222
Sea bass, fresh	7,856	656	10,800	640	11,000	780	11,300	970	40,956	3,046
Scup, fresh	6,800	170	.....	.....	.....	.....	.....	.....	6,800	170
Shad, fresh	1,925	87	141,880	11,979	19,147	1,515	32,900	2,999	195,852	16,580
Smelt, fresh	11,200	850	.....	.....	.....	.....	1,600	192	12,800	1,042
Squeteague, fresh	172,340	6,443	.....	.....	14,000	690	18,140	1,060	204,480	8,193
Striped bass, fresh	24,970	2,470	1,000	80	1,500	100	11,300	780	38,770	3,430
Tautog, fresh	140,300	6,525	25,000	1,250	27,600	1,430	24,400	1,200	217,300	10,405
Whiting, fresh	11,640	174	.....	.....	.....	.....	.....	.....	11,640	174
Miscellaneous fish, fresh	92,360	469	142,000	535	72,500	855	.....	.....	306,860	1,859
Lobsters	887,700	45,355	61,000	3,380	88,000	6,600	17,700	1,700	1,054,400	57,035
Crabs	8,300	300	.....	.....	.....	.....	.....	.....	8,300	300
Terrapin	.....	.....	.....	.....	.....	.....	3,057	1,280	3,057	1,280
Clams (soft)	12,600	1,530	62,000	7,200	101,500	9,180	87,500	6,990	263,600	24,900
Quahogs	456	99	.....	.....	42,360	4,905	124,480	15,710	167,296	20,714
Scallops	.....	.....	.....	.....	.....	.....	2,700	230	2,700	230
Oysters	15,120	4,165	61,600	9,225	927,773	90,595	1,063,769	121,122	2,068,262	225,107
Oyster shells	.....	.....	.....	.....	.....	.....	7,800,000	6,500	7,800,000	6,500
Algæ	7,190,000	2,706	6,500,000	810	2,170,000	860	2,800,000	527	18,660,000	4,903
Total	9,381,109	95,740	7,504,109	46,691	9,830,186	133,303	12,250,056	174,685	38,965,460	450,419

The quantities and values of products taken in each of the principal forms of apparatus employed in the shore fisheries are shown in the next table. Pound nets and trap nets are the most important means of capture employed in taking fish proper; the yield was 7,556,665 pounds, worth $43,288. Lines rank next as far as the value of the fish is concerned, but fyke nets catch larger quantities of fish. If lobsters are considered, pots produce larger returns than pound nets and trap nets, the stock in 1889 being $71,450. Dredges, tongs, rakes, and other miscellaneous apparatus naturally secured the largest quantities of products, which consisted chiefly of shellfish.

126.—Table showing by counties and apparatus the yield of the shore fisheries of Connecticut in 1889.

Apparatus and species.	New London.		Middlesex.		New Haven.		Fairfield.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Pound nets and trap nets:										
Alewives, fresh	3,280	$165	39,392	$265	8,600	$225			51,272	$655
Bluefish, fresh	7,550	391							7,550	391
Butter-fish, fresh	35,000	914			7,400	150			42,400	1,064
Cod, fresh	45	2							45	2
Flatfish and flounders, fresh	183,900	3,551	7,000	140					190,900	3,691
Frostfish, fresh	600	15					55,000	$2,500	55,600	2,515
Mackerel, fresh	4,330	620							4,330	620
Menhaden, fresh	18,667	87	327,227	658	6,209,986	12,575			6,555,880	13,320
Salmon, fresh			260	204	20	18			280	222
Scup, fresh	6,800	170							6,800	170
Sea bass, fresh	2,006	201							2,006	201
Shad, fresh	1,925	87	89,730	7,847	15,997	1,255			107,652	9,189
Squeteague, fresh	164,000	5,865			6,000	240			170,000	6,105
Striped bass, fresh	24,350	2,410							24,350	2,410
Tautog, fresh	19,100	700							19,100	700
Whiting, fresh	11,640	174							11,640	174
Miscellaneous, fresh	92,360	469	142,000	535	72,500	855			306,860	1,859
Total	575,553	15,821	605,609	9,649	6,320,503	15,318	55,000	2,500	7,556,665	43,288
Seines:										
Alewives, fresh			2,000	15					2,000	15
Bluefish, fresh							3,060	205	3,060	205
Eels, fresh							100	10	100	10
Flatfish and flounders, fresh							13,500	310	13,500	310
Frostfish, fresh							9,400	350	9,400	350
Shad, fresh					3,150	260	18,900	1,719	22,050	1,979
Smelt, fresh	9,000	700					1,600	192	10,600	892
Squeteague, fresh	400	25					6,440	395	6,840	420
Striped bass, fresh			400	35			6,050	450	6,450	485
Total	9,400	725	2,400	50	3,150	260	59,050	3,631	74,000	4,666
Gill nets:										
Bluefish, fresh	870	77			4,000	200	500	35	5,370	312
Menhaden, fresh	500	2			30,000	60			30,500	62
Shad, fresh			52,150	4,132			14,000	1,280	66,150	5,412
Squeteague, fresh	7,940	553			6,000	300	300	15	14,240	868
Striped bass, fresh	620	60							620	60
Total	9,930	692	52,150	4,132	40,000	560	14,800	1,330	116,880	6,714
Fyke nets:										
Flatfish and flounders, fresh	325,700	6,429	1,200	30	4,500	100	16,000	340	347,400	6,899
Frostfish, fresh	21,000	485					5,000	175	26,000	660
Menhaden, fresh					66,500	375			66,500	375
Striped bass, fresh			600	45	1,500	100	5,250	330	7,350	475
Tautog, fresh	8,000	350							8,000	350
Total	354,700	7,264	1,800	75	72,500	575	26,250	845	455,250	8,759

126.—Table showing by counties and apparatus the yield of the shore fisheries of Connecticut in 1889—Cont'd.

Apparatus and species.	New London.		Middlesex.		New Haven.		Fairfield.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Lines:										
Bluefish, fresh	24,100	$1,355			8,300	$750	15,250	$1,400	47,650	$3,505
Cod, fresh	6,400	320							6,400	320
Cunners, fresh			5,000	$200					5,000	200
Flatfish and flounders, fresh	12,000	290					44,000	1,225	56,000	1,515
Frostfish, fresh							32,500	1,350	32,500	1,350
Haddock, fresh	6,300	290							6,300	290
Mackerel, fresh	3,000	360							3,000	360
Sea bass, fresh	5,850	455	10,800	640	11,000	780	11,300	970	38,950	2,845
Smelt, fresh	2,200	150							2,200	150
Squeteague, fresh					2,000	150	11,400	650	13,400	800
Tautog, fresh	113,200	5,475	25,000	1,250	27,600	1,430	24,400	1,200	190,200	9,355
Total	173,050	8,695	40,800	2,090	48,900	3,110	138,850	6,795	401,600	20,690
Spears:										
Eels, fresh	91,000	5,700	33,000	3,320	8,400	780	6,500	705	138,900	10,505
Flatfish and flounders, fresh	4,400	93					14,000	320	18,400	413
Total	95,400	5,793	33,000	3,320	8,400	780	20,500	1,025	157,300	10,918
Pots:										
Eels, fresh	48,900	2,595	83,750	6,760	7,100	560	36,400	4,500	176,150	14,415
Lobsters	887,700	45,355	61,000	3,380	88,000	6,600	17,700	1,700	1,054,400	57,035
Total	936,600	47,950	144,750	10,140	95,100	7,160	54,100	6,200	1,230,550	71,450
Miscellaneous:										
Crabs	8,300	300							8,300	300
Clams (soft)	12,600	1,530	62,000	7,200	101,500	9,180	87,500	6,990	263,600	24,900
Quahogs	456	99			42,360	4,905	124,480	15,710	167,296	20,714
Scallops							2,700	230	2,700	230
Oysters	15,120	4,165	61,600	9,225	927,773	90,595	1,063,769	121,122	2,068,262	225,107
Oyster shells							7,800,000	6,500	7,800,000	6,500
Terrapin							3,057	1,280	3,057	1,280
Algæ	7,190,000	2,706	6,500,000	810	2,170,000	860	2,800,000	527	18,660,000	4,903
Total	7,226,476	8,800	6,623,600	17,235	3,241,633	105,540	11,881,506	152,359	28,973,215	283,934
Grand total	9,381,109	95,740	7,504,109	46,691	9,830,186	133,303	12,250,056	174,685	38,965,460	450,419

The following table, made up from the foregoing, shows the great relative difference in the effectiveness of various forms of apparatus, and the marked dissimilarity which exists between the quantity and value of the fish and other products procured by the different means.

127.—Table showing the relative quantity and value of yield in each principal form of apparatus of capture employed in the shore fisheries of Connecticut in 1889.

Apparatus.	Percentage.	
	Quantity.	Value.
Seines	.19	1.04
Gill nets	.30	1.49
Pound nets and trap nets	19.39	9.61
Fyke nets	1.17	1.95
Hand and trawl lines	1.03	4.59
Pots	3.16	15.86
Spears	.40	2.42
Miscellaneous	74.36	63.04
Total	100.00	100.00

A table of averages and percentages is next given and discloses some interesting facts. The average value of catch for each man engaged in the shore fisheries varied from $256 in Middlesex County to $481 in New Haven County. The average stock for each $100 invested in boats ranged from $379 in Fairfield County to $583 in Middlesex County. The average value of catch per each $100 invested in apparatus has a wide range, from $187 in Middlesex County to $4,367 in Fairfield County, the fishermen in the latter county taking mostly products of a relatively high price with a comparatively inexpensive kind of apparatus. The percentage of the value of the catch with each form of apparatus is shown for the various counties.

128.—Table showing by counties certain averages and percentages of the shore fisheries of Connecticut in 1889

Counties.	Value of catch per each $100 invested in boats.	Value of catch per each $100 invested in apparatus.	Value of catch per each man employed.	Percentage of value of yield in principal forms of apparatus.								
				Total.	Pound nets and trap nets.	Seines.	Gill nets.	Fyke nets.	Lines.	Pots.	Spears.	Miscellaneous.
New London	$452	$312	$388	100.00	16.53	.76	.72	7.59	9.08	50.08	6.05	9.19
Middlesex	583	187	256	100.00	20.66	.11	8.85	.16	4.48	21.72	7.11	36.91
New Haven	572	1,084	481	100.00	11.49	.20	.42	.43	2.33	5.37	.59	79.17
Fairfield	379	4,367	320	100.00	1.43	2.08	.76	.48	3.89	3.55	.59	87.22

The relative importance of each species in the different counties is next exhibited, the figures presenting the percentage of the value of the various products to the total stock in each county.

129.—Table showing by counties the percentage of value of each species to the total yield of the shore fisheries of Connecticut in 1889.

Species.	New London.	Middlesex.	New Haven.	Fairfield.
Alewives, fresh	.17	.60	.17	
Bluefish, fresh	1.91		.71	.94
Butter-fish, fresh	.96		.11	
Cod, fresh	.34			
Cunners, fresh		.43		
Eels, fresh	8.66	21.59	1.01	2.99
Flatfish and flounders, fresh	10.83	.36	.07	1.26
Frostfish or tomcod, fresh	.52			2.50
Haddock, fresh	.30			
Mackerel, fresh	1.02			
Menhaden, fresh	.09	1.41	9.76	
Salmon, fresh		.46	.01	
Sea bass, fresh	.68	1.35	.59	.56
Scup, fresh	.18			
Shad, fresh	.09	25.66	1.14	1.72
Smelt, fresh	.89			.11
Squeteague, fresh	6.73		.52	.61
Striped bass, fresh	2.58	.17	.07	.45
Tautog, fresh	6.82	2.68	1.07	.69
Whiting, fresh	.18			
Miscellaneous fish, fresh	.49	1.14	.64	
Lobsters	47.37	7.24	4.95	.97
Crabs	.31			
Terrapin				.73
Clams, soft	1.60	15.42	6.89	4.00
Quahogs	.10		3.68	8.99
Scallops				.13
Oysters	4.35	19.76	67.96	69.34
Oyster shells				3.71
Algæ	2.83	1.73	.65	.30
Total	100.00	100.00	100.00	100.00

THE MENHADEN INDUSTRY.

Connecticut ranks next to Rhode Island in the extent of its menhaden industry. The four factories at which the crude fish are utilized employed 215 men as fishermen and shoresmen, and, with the necessary cash capital, were valued at $108,700. Six steam vessels and 4 sailing vessels were employed, the value of which was $73,655; giving, as the total amount of capital invested in this enterprise, $182,355. In 1889 37,360,700 menhaden were handled, the value of which was $52,927. The manufactured products had a market value of $99,066, an increase of $51,601 over 1887 and $30,536 over 1888.

130.—Table showing the extent of the menhaden industry of Connecticut in 1889.

Number of factories in operation	4
Value of factories	$83,200
Amount of cash capital	$25,500
Number of shoresmen employed	82
Number of fishermen employed	133
Number of steam vessels employed	6
Net tonnage	451.80
Value	$61,500
Value of outfit	$10,000
Number of sailing vessels employed as "carryaways"	4
Net tonnage	41.49
Value	$1,835
Value of outfit	$320
Number of menhaden handled	37,360,700
Value to fishermen	$52,927
Number of gallons of oil made	233,228
Value as sold	$53,110
Number of tons of scrap produced	2,893
Value as sold	$45,956

6.—REPORT ON AN INVESTIGATION OF THE FISHERIES OF LAKE ONTARIO.

BY HUGH M. SMITH, M. D.

[Plates XXI to L.]

PREFATORY NOTE.

The fisheries of Lake Ontario have recently received much attention, especially among citizens of that portion of northern New York bordering on the lake, and the past and present condition of the industry has been a fertile subject of local discussion and general interest. The scarcity of certain fish that formerly abounded in the lake and the possibility of a further decrease in those and other species have been the basis for an agitation which has become one of the most noteworthy movements of the kind in recent years. Fish and game clubs, anglers' associations, and economic and trade organizations have given the matter consideration; sporting and industrial publications have contained numerous and detailed accounts of the progress of the movement; the daily press has noticed the subject editorially and opened its columns to correspondence and news; conferences have been held between representatives of the two countries immediately interested in the preservation of the lake fisheries; the New York legislature has provided for a new code of fishery laws with a view to secure better protection to the fish, and the national Congress has made provision for the establishment of a fish-hatching station on or near Lake Ontario.

In 1891 the U. S. Commission of Fish and Fisheries undertook an investigation of the commercial fisheries of the Great Lakes, under the direction of Capt. J. W. Collins, the assistant in charge of the Division of Fisheries. The subjects embraced by the inquiry included, among others, the following points: (1) Complete statistics of the number of persons employed; the number and value of vessels, boats, and apparatus used; the quantity and value of each species of fish taken; the wholesale fish trade; the extent of fisheries in Canadian waters operated, owned, or controlled by American citizens, and such other phases of the industry as can be expressed in figures. (2) A history of the changes in the methods and relations of the fisheries that have occurred since the last investigation in 1885, when a detailed report* was issued covering the lake fisheries. (3) A determination of the effects of artificial propagation in preserving and increasing the supply of food-fishes in the Great Lakes.

The investigation of the fisheries of Lake Ontario was conducted by the writer during the months of August and September, 1891, the data obtained at that time serving as a basis for the accompanying remarks.

*A Review of the Fisheries of the Great Lakes in 1885, compiled by Hugh M. Smith and Merwin-Marie Snell, with introduction and description of fishing vessels and boats, by J. W. Collins. 8°, pp. 333, 44 plates and folding maps. Report of Commissioner of Fish and Fisheries, 1887.

The information presented in this paper includes a brief account of the physical characteristics of the lake as far as they may have influence on the fish and fisheries; statistics showing the extent of the commercial fisheries in each county on the lake, with a consideration of the present and past importance of the lake fisheries; an exhibition of the extent of the import trade in Canadian fish, with a discussion of the same; remarks on certain fishes of economic importance; and a suggestion of the steps necessary for the improvement of the fisheries.

PHYSICAL CHARACTERISTICS OF LAKE ONTARIO.

A thorough study of the physical conditions of Lake Ontario is necessary for and must antedate a comprehensive knowledge of the fish fauna. Temperature, depth of water, character of bottom, currents, winds, and sediment all have important bearings on the movements, habits, and abundance of fishes. Unfortunately, such an investigation has never been undertaken, and it is only possible to present a few facts having a general application.

Ontario is much the smallest of the Great Lakes. Its maximum length is 185 miles, and its greatest width, opposite Irondequoit Bay, is 55 miles; the average breadth is about 40 miles. The area is about 6,500 square miles, of which some 2,700 square miles are within the jurisdiction of the State of New York, and the remaining portion is controlled by the government of Canada. The province of Ontario occupies the entire northern and western and a part of the southern shores, leaving only the eastern portion of the southern side abutting on New York. The shores, following the major indentations, are 565 miles in length, of which New York occupies about 265 miles.

The surface of the lake is 232 feet above the level of the sea, although the mean level is subject to considerable variation within limits which are necessarily somewhat narrow. In 1891 the surface of the lake was lower than for many years, and toward the end of the season was said to be fully 3 feet below the mean level. This was due in a measure to the small quantity of water brought down by the tributary streams, and also to the reduction in the supply coming from the upper lakes. Persons familiar with Niagara Falls were heard to comment on the diminution in the amount of water passing through the river basin at certain periods during the summer.

Lake Ontario has a much greater average depth than the adjoining member of the chain, Lake Erie; this feature is of considerable importance in connection with the movements and distribution of fish. The eastern end of the lake is much the shallowest portion, the western extremity is somewhat deeper than the eastern, while the deepest water is found near the middle of the lake in the region of its greatest width. That part of the lake which is below or to the north of the chain of small islands, extending from Stony Point on the east to South Bay Point on the west, and which contains the most important fishing-grounds for whitefish, trout, and pike perch, varies in depth from 30 to 180 feet, and has an average depth of about 100 feet. A number of small shoals occur which serve as spawning-grounds for whitefish and trout. One of the most important of these is Charity Shoal, situated 6 miles west of Grenadier Island, which is the ground most resorted to by the trap-net fishermen of Jefferson County. In the middle and western portions of the lake the water, toward the middle, has a depth varying from 200 to over 700 feet, the average being about 400 feet. The deepest soundings made by the engineer corps of the U. S. Army were 13 miles from the American shore in a direction NNW. from Sodus Point; here the water was 738

feet deep. Other soundings of 600 feet and over are numerous in that portion of the lake south of the international boundary, opposite that part of the State of New York between Rochester and Oswego, at distances varying from 7 to 15 miles from the shore. No water of this depth occurs in the Canadian portion of the lake. The deep water approaches nearest to the shore opposite the eastern county line of Monroe County; here, at a distance of a little less than 7 miles from the shore, the depth of water is 636 feet.

A favorable feature of the lake, so far as fish are concerned, is the varying character of the bottom. Some of the most important of the lake fishes are bottom feeders, and the quantity and variety of small animal and vegetable organisms which comprise the food of these species largely depend on the nature of the bottom. That portion of the lake north of a line drawn west from Stony Point is characterized by a rocky and sandy bottom; the remaining part is mostly muddy, with small areas of sand and clay. It would be extremely interesting to know to what extent the distribution and movements of such bottom feeders as the whitefish, herring, and sturgeon are influenced by the nature of the bottom.

PRESENT AND PAST CONDITION OF LAKE ONTARIO FISHERIES.

The following tables, which relate to the year 1890, present the salient features of the fisheries of the lake and show the extent of the industry in each county.

The first table gives the number of persons engaged in the fisheries in different capacities. The use of vessels has never been a prominent feature of the fisheries of this lake, and in 1890 only 11 men were employed on vessels. The wholesale trade in fish, which has a very intimate connection with the fisheries proper and is included in the statistics so far as the personnel and capital are concerned, gave employment to 22 persons. The shore fisheries, prosecuted from boats and from the shore, had the services of 356 men. Jefferson County, at the extreme eastern end of the lake, had 172 persons engaged in the fisheries, a greater number than in any other two counties combined. Oswego County ranked second in the number of fishermen, with 62, followed by Niagara, with 54. Cayuga and Orleans Counties had 15 and 17 respectively.

The number and value of vessels and boats, the quantity and value of apparatus, and the amount of cash capital and shore property employed in the fisheries of Lake Ontario are shown in the next table. The total investment in the industry was $123,533, of which sum Jefferson County is to be credited with $95,208, a circumstance illustrating the great relative importance of the fisheries in that county. The three vessels employed were valued at $9,585, and the 373 boats were worth $21,577. The most important forms of apparatus were the trap nets and pound nets, of which 288 were operated, valued at $24,577. Gill nets with a combined length of 1,103,945 feet, worth $18,110, were employed, and constituted the next prominent apparatus.

The quantity and value of each important species taken in 1890 are shown in the third table. The aggregate catch was 3,446,448 pounds, for which the fishermen received $124,786. The species of which the greatest quantity was caught were the cisco and the other minor varieties of whitefish classed in the tables under the general name of herring, but both pike perch and sturgeon yielded larger returns than the herring. The output in Jefferson County was much in excess of that of all the other

counties combined, and amounted to 2,416,458 pounds, valued at $90,142. The quantities given in the tables represent, in all cases, the weight of the fish as taken from the water.

One of the most interesting subjects involved in a discussion of the lake fisheries is the relative effectiveness of the different forms of apparatus employed in the capture of fish. This is clearly brought out in the last table of the series, the quantity and value of the species taken in each of the principal devices being shown. Gill nets take the largest quantities of fish and yield the greatest money returns, the specially prominent species thus caught being herring and sturgeon. Trap nets and pound nets closely follow gill nets, the pike perch being the most valuable species. Among the minor kinds of apparatus, fyke nets rank first in the amount of catch, after which come lines, seines, and miscellaneous forms.

Table showing by counties and nature of employment the number of persons (citizens of New York) engaged in the fisheries of Lake Ontario in 1890.

Counties.	In vessel fishery.	In shore fishery.	On shore.	Total.
Jefferson	4	152	16	172
Oswego	5	53	4	62
Cayuga	2	11	2	15
Wayne		41		41
Monroe		28		28
Orleans		17		17
Niagara		54		54
Total	11	356	22	389

Table showing by counties the number and value of vessels, boats, and apparatus, and the value of shore property and cash capital employed by New York fishermen in the fisheries of Lake Ontario in 1890.

Designation.	Jefferson.		Oswego.		Cayuga.		Wayne.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Vessels	1	$5,880	1	$3,300	1	$405		
Boats	202	15,700	48	1,390	13	595	54	$2,245
Gill nets, feet	696,425	10,911	57,180	792	18,315	296	66,591	935
Pound and trap nets	286	24,455					2	122
Fyke nets	458	6,850	140	2,100	26	315	39	365
Seines	3	60	4	240			2	60
Set lines, feet	17,182	35	37,200	75			1,210	4
Miscellaneous apparatus		45		4				
Shore property		18,882		3,980		260		1,525
Cash capital		12,390		500				
Total		95,208		12,381		1,871		5,256

Designation.	Monroe.		Orleans.		Niagara.		Total for the State.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Vessels							3	$9,585
Boats	20	$472	11	$305	25	$870	373	21,577
Gill nets, feet	42,240	434	76,395	1,775	146,799	2,967	1,103,945	18,110
Pound and trap nets							288	24,577
Fyke nets	21	192					684	9,822
Seines	4	48			14	248	27	656
Set lines, feet			59,200	296	24,840	80	139,632	490
Miscellaneous apparatus								49
Shore property		606		71		453		25,777
Cash capital								12,890
Total		1,752		2,447		4,618		123,533

Table showing by counties and species the quantities and values of fish taken by New York fishermen in Lake Ontario in 1890.

Species.	Jefferson.		Oswego.		Cayuga.		Wayne.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Black bass	11,855	$1,058	6,201	$340	2,676	$148	3,993	$231
Bullheads and catfish	315,711	8,360	108,650	2,173	15,100	302	16,030	757
Eels	247,490	8,396	3,600	188	910	44	2,890	173
Herring	369,334	14,199	24,525	981	1,600	48	26,210	776
Perch	241,520	2,383	70,600	1,765	3,960	109	33,985	715
Pike (*Esox*)	39,950	1,595	61,795	3,361	10,370	483	15,060	753
Pike perch	296,832	26,955	24,673	1,245	3,454	172	1,900	76
Sturgeon	374,235	14,949	22,532	1,083	.....	.....	2,330	70
Suckers	168,820	1,900	51,115	935	4,865	72	5,410	113
Trout	40,400	2,048	500	30	.....	.....	.....	.....
Whitefish	143,771	6,517	3,550	213	.....	.....	720	72
Other fish	166,540	1,782	67,880	1,697	4,498	72	9,480	124
Total	2,416,458	90,142	445,621	14,011	47,433	1,430	118,008	3,860

Species.	Monroe.		Orleans.		Niagara.		Total for the State.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Black bass	2,800	$224	3,000	$210	2,567	$153	33,092	$2,364
Bullheads and catfish	11,564	653	1,500	30	3,400	169	471,955	12,444
Eels	2,300	112	.....	.....	.....	.....	257,190	8,913
Herring	10,960	438	6,000	120	160,349	4,374	598,978	20,936
Perch	4,115	245	1,150	35	3,617	116	358,947	5,368
Pike (*Esox*)	2,000	100	.....	.....	315	12	129,490	6,284
Pike perch	.....	.....	.....	.....	4,143	281	331,002	28,729
Sturgeon	.....	.....	90,675	3,830	51,980	2,359	541,752	22,291
Suckers	7,420	312	910	27	40,630	1,219	279,170	4,578
Trout	.....	.....	.....	.....	110	11	41,010	2,089
Whitefish	.....	.....	.....	.....	730	73	148,771	6,875
Other fish	2,753	129	440	13	3,500	98	255,091	3,915
Total	43,912	2,213	103,675	4,265	271,341	8,865	3,446,448	124,786

Table showing by apparatus and species the quantities and values of fish taken by New York fishermen in Lake Ontario in 1890.

Species.	Gill nets.		Pound nets and trap nets.		Fyke nets.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Black bass	23,284	$1,547	6,488	$623	.....	.....
Bullheads and catfish	8,530	330	49,010	1,222	400,273	$10,484
Eels	.....	.....	196,204	6,550	56,336	2,177
Herring	586,629	20,516	5,724	161	.....	.....
Perch	30,210	648	150,975	1,427	170,645	3,111
Pike (*Esox*)	41,740	2,032	520	26	73,770	3,340
Pike perch	26,970	1,330	297,132	26,967	.....	.....
Sturgeon	428,919	17,607	26,075	992	.....	.....
Suckers	13,580	351	93,800	938	76,320	1,056
Trout	10,637	566	30,181	1,513	.....	.....
Whitefish	78,249	3,717	68,392	3,007	.....	.....
Other fish	8,968	177	120,350	1,278	122,183	2,398
Total	1,257,716	48,821	1,044,851	44,704	899,527	22,561

Species.	Seines.		Lines.		Minor apparatus.		Total apparatus.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Black bass	1,967	$118	1,353	$76	.....	.....	33,092	$2,364
Bullheads and catfish	6,735	240	2,847	77	4,560	$91	471,955	12,444
Eels	.....	.....	4,650	186	.....	.....	257,190	8,913
Herring	6,625	259	.....	.....	.....	.....	598,978	20,936
Perch	6,117	162	1,000	20	.....	.....	358,947	5,368
Pike (*Esox*)	1,685	81	9,275	730	2,500	75	129,490	6,284
Pike perch	4,718	312	2,182	120	.....	.....	331,002	28,729
Sturgeon	2,480	78	84,068	3,608	210	6	541,752	22,291
Suckers	44,580	1,290	1,250	25	49,640	918	279,170	4,578
Trout	.....	.....	192	10	.....	.....	41,010	2,089
Whitefish	2,130	151	.....	.....	.....	.....	148,771	6,875
Other fish	3,590	67	.....	.....	.....	.....	255,091	3,915
Total	80,627	2,758	106,817	4,852	56,910	1,090	3,446,448	124,786

The fisheries on the Canadian shores of Lake Ontario which are controlled by dealers on the southern shores of that lake gave employment to 92 fishermen in 1891; the value of the boats, apparatus, etc., used was $8,860; and the products were as given in the chapter on imports.

In Jefferson County the fishermen selling to local dealers received the following prices for their fish in 1890 and 1891. The figures do not differ materially from those obtained in other regions, and may be taken as a general average for the entire lake. The average prices paid by dealers are somewhat less than those received by the American fishermen, for the reason that the Canadian fish bring rather lower prices than those taken in home waters, the output being controlled by the dealers.

Average wholesale prices per pound received by the fishermen of Jefferson County, New York.

Species.	1890.	1891.
	Cents.	Cents.
Wall-eyed pike or pike perch	10	6
Black bass	10	5½
Whitefish*	6½	6
Trout*	6½	6
Sturgeon†	6	5
Muskellunge	5	5
Pike or pickerel	4	4
Bullheads and catfish†	4	4
Eels	3½	4
Ciscoes	3	3
Perch	1	1
Suckers	1	1
Sheepshead	1	1
White bass	1	1

*The prices given were for dressed fish, which represent about three-fourths the original weight.
†The prices given were for dressed fish, which represent about two-thirds the round weight.

One of the most valuable uses of statistics is the opportunity they afford for noting comparisons between different years, and recourse to this advantage is nowhere more important and necessary than in the fisheries, especially in cases in which it becomes desirable to gauge accurately the effects of fish-culture.

Comparing the present and past extent of the fisheries of Lake Ontario, it is seen, in the first place, that since 1880 the decrease in the number of persons employed in the fisheries has been 223, and since 1885, which was probably the most prosperous year during the decade, the decrease has been 211.

The amount of capital devoted to fishing appears to have increased considerably since 1880, although there has been a decline in this respect since 1885. The principal factor in the increase is the shore property and working capital, which in 1880 amounted to only $5,000, and in 1890 to $38,667; the latter sum represents chiefly the wholesale handling of fish by firms on the lake shore, a business which is so intimately connected with actual fishing that it has been included in the foregoing tables. The investment in steam and sail vessels and boats is also much larger than in 1880, the increase being $19,062 and being due to the employment of more boats, required by the prosecution of fisheries of a more varying character than was demanded in 1880, when the most important species were abundant; there has also been an improvement in the type of steamers used in the fisheries. The apparatus employed in 1890 was worth $7,756 more than in 1880, an increase due entirely to the use of greater quantities of

trap nets and fyke nets, while the quantity and value of gill nets have been reduced. Compared with 1885, the diminution in the amount of investment has been $12,216, made up chiefly of pound nets, shore property, and cash capital.

The most interesting comparison, however, is that which shows the past and present catch of the different species, a subject which is of the utmost importance at this time, in that the figures must serve as a basis for determining the result of artificial propagation, which it is hoped will soon be undertaken on a large scale.

It will probably occasion some surprise to state that the aggregate yield of the fisheries of Lake Ontario in 1890 was but little less than in 1880, the decrease in quantity of fish amounting to only 5.32 per cent, and in the value of catch only 2.19 per cent; when it is considered, however, that a more unfavorable general showing has been prevented only by the capture of larger quantities of the cheaper grades of fish, and that the output of the two most valuable species in 1880 has been reduced 88.38 per cent, the matter assumes a different phase. In the following table the catch of whitefish, trout, sturgeon, herring, and other species in 1880 and 1890 is shown, together with the increase or decrease and the percentage of increase or decrease. The aggregate value of the output each year, the reduction in the value, and the percentage of decline are also given.

Comparative table showing the output of the fisheries of Lake Ontario in 1880 and 1890.

Species.	1880.	1890.	Increase or decrease.	
			Quantity.	Percentage.
	Pounds.	*Pounds.*	*Pounds.*	
Whitefish	1,064,000	148,771	— 915,229	— 86.02
Trout	569,700	41,010	— 528,690	— 92.80
Sturgeon	545,283	541,752	— 3,531	— .65
Herring	611,217	598,978	— 12,239	— 2.00
All others	849,800	2,115,937	+1,266,137	+147.11
Total	3,640,000	3,446,448	— 193,552	— 5.32
Total value	$159,700	$124,786	— $34,913	— 2.19

THE CANADIAN IMPORT TRADE.

A discussion of the fisheries of Lake Ontario would be incomplete without some allusion to the extent of the international trade depending on the prosecution of the industry on the Canadian side of the lake. The province of Ontario occupies the entire northern and a portion of the southern shores of the lake, and the fisheries therein are more or less dependent for their successful maintenance on the markets of the United States; on the other hand, consumers of fish in many parts of New York are, to a considerable extent, dependent for their supply on the Canadian fisheries.

During the first three quarters of the year 1890 fresh fish were admitted into United States ports free of duty, but on October 1 of that year the new tariff went into effect, which provides that only those fish caught in apparatus belonging to citizens of the United States are entitled to free entry. Persons importing fish free of duty are now required to make the following oath:

I, ——— ———, residing at ——— ———, a citizen of the United States, do solemnly swear that all of the fish imported by me in the [name of vessel] from [name of foreign port] on the ——— day of ———, 18—, viz, ——— pounds, are fresh fish (not salmon), and that they were caught in fresh water by nets and other devices which are owned by citizens of the United States.

Contrary to what might have been expected, the imports of free fish in 1891 were in no respect diminished by the tariff law, but, as shown by the following tables, based on figures compiled from official custom-house records, the receipts in 1891 were considerably in excess of 1890, except in one district, in which the imports in 1890 were from fisheries in which Americans were not interested. The explanation is that the American dealers purchased or furnished the apparatus of the Canadian fishermen from whom they obtained fish, and the increased importation represents an increased output and a more extended demand, the conditions of trade in the two years being essentially similar.

Table showing by customs districts the quantity of fresh fish, free of duty, imported into the United States from the Canadian shore of Lake Ontario in 1890 and 1891.

Quarters.	Cape Vincent.	Oswego.	Genesee.	Total.
1890.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
First	70,000	.....	.....	70,000
Second	341,211	81,853	103,900	526,964
Third	239,928	30,582	60,550	331,060
Fourth	82,790	33,851	1,800	118,441
Total	733,929	146,286	166,250	1,046,465
1891.				
First	118,000	.....	(*)	118,000
Second	286,062	109,209	(*)	395,271
Third	305,589	34,176	(*)	339,765
Fourth	286,350	25,315	(*)	311,665
Total	996,001	168,700	(*)	1,164,701

* No free fish imported in 1891.

A comparison of the receipts for the two years shows that in the two districts in which the imports represent fish from Canadian fisheries operated or controlled by American capital, the increase of 1891 over 1890 was 284,486 pounds, and the net increase for all districts was 118,236 pounds. The imports of free fish into the Genesee district, which in 1890 amounted to 166,250 pounds, were entirely cut off in 1891 by the tariff, although a few thousand pounds of dutiable fish were imported.

Trout and whitefish are the most important fish brought in from Canada, although all the other commercial species of the lake are imported in greater or less quantities, among which yellow perch, pike (*Esox lucius*), sturgeon, lake herring, bullheads, and wall-eyed pike may be especially mentioned.

It is only in the Cape Vincent district that figures are available showing the quantities of whitefish, trout, and other species imported. The following tabular presentation will therefore prove of interest and will serve as a basis for determining the approximate proportions for the entire lake:

Table showing the quantities of whitefish, trout, and other species imported free of duty into the Cape Vincent district during each quarter of the years 1890 and 1891.

Quarters.	Whitefish.		Trout.		All other species.		Total.	
	1890.	1891.	1890.	1891.	1890.	1891.	1890.	1891.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
First	2,100	10,390	275	.....	67,625	107,610	70,000	118,000
Second	66,747	47,163	14,144	25,027	260,320	213,872	341,211	286,062
Third	115,216	141,544	18,712	17,086	106,000	146,959	239,928	305,589
Fourth	13,695	70,964	3,240	12,343	65,855	203,043	82,790	286,350
Total	197,758	270,061	36,371	54,456	499,800	671,484	733,929	996,001

It is seen that in 1890 whitefish constituted about 27 per cent of the fish imported from Canada, trout 4 per cent, and other species 69 per cent. In 1891 the proportions were 27 per cent, 5 per cent, and 68 per cent, respectively. Applying these figures to the entire lake it appears that the Canadian fisheries of Lake Ontario furnished to United States markets in 1890 about 282,545 pounds of whitefish, 41,859 pounds of trout, and 722,061 pounds of miscellaneous fish; while in 1891 there were 314,469 pounds of whitefish, 58,235 pounds of trout, and 791,997 pounds of all other fish.

The fish brought into the Cape Vincent and Oswego districts are chiefly obtained at the Duck Islands and in the Bay of Quinte, near the eastern end of the lake; they are collected from the various fishing stations by vessels sent out by the dealers. The receipts in the Genesee district in 1890 were chiefly from Port Hope, and were landed by regular passenger and freight steamers.

The greater prolificness of the Canadian waters at the present time in whitefish and trout, which is hereinafter alluded to in the chapter on the whitefish, is well illustrated by the foregoing table. The difference in the output of the two sides becomes even more marked in view of the fact that the imports represent only a portion of the yield of the Canadian fisheries.

NOTES ON IMPORTANT COMMERCIAL FISHES OF LAKE ONTARIO.

The principal commercial fishes of Lake Ontario are reviewed somewhat in detail in this chapter. The information is not intended to include a life history of the species considered. Even if the circumstances incident to the collection of the data had permitted thorough study, such work would have been supererogatory in view of the elaborate biographies already extant. The species have been discussed primarily from an economic standpoint, although certain information concerning their habits and movements is introduced which has a bearing on the practical side of the question and is thought to add something to the present knowledge of the fish life of the lake.

THE STURGEON.

The sturgeon (*Acipenser rubicundus*), the largest and one of the most important and valuable of the lake fishes, has decreased in abundance since 1880. In that year 545,283 pounds were taken; in 1885 the catch was 386,974 pounds; in 1890, as a result of increased demand, 490,000 pounds were obtained. At one time there was little value placed on the sturgeon, which was regarded as almost unfit for food, and, as on the other lakes, the fish was unnecessarily persecuted and often wantonly destroyed. Now it brings the fishermen the same price per pound as whitefish and trout.

Under the name of "rock sturgeon" the fishermen of the St. Lawrence River and Lake Ontario recognize the small fish caught almost entirely during the summer months, when the larger sturgeon are spawning and are only occasionally taken. It has very prominent scales and a long snout as its principal differential features, and is regarded by many fishermen as a distinct species. It weighs from 10 to 25 pounds.

While it is known that the sturgeon is a bottom feeder, and that the shape of the mouth and the general anatomy must determine the character of its food, much yet remains to be learned concerning the food and the food habits of the fish.

Milner, whose studies of the Great Lake fishes were the most complete ever made, writes as follows on this question:

> Their [the sturgeons'] food consists almost entirely of the shellfish of the lakes, principally gastropods, the thinner-shelled kinds of the genera *Physa*, *Planorbis*, and *Valvata* being found broken in the stomachs, while *Limnæa* and *Melantho* remain whole. A few eggs of fishes have been found at different times, but examination of stomachs during the spawning season of the most numerous fishes did not prove them to be very extensive spawn-eaters.*

A few observations can be recorded which are thought to add to the published information on this subject. In June, 1891, a sturgeon weighing 150 pounds was taken at Oswego, New York, which was found to be filled to its utmost capacity with wheat. The fish had evidently been feeding under the grain elevators on the Oswego River. Individual specimens are also occasionally caught in Lake Ontario with corn in their stomachs. A favorite food at times is the crayfish, which occurs abundantly in the lake and is commonly known as the "crab" among fishermen; sturgeon have been eviscerated at Oswego and elsewhere with large quantities of this crustacean in their alimentary tracts. The fishermen often use these "crabs" as bait on their set lines and secure fish when all other kinds of bait fail to attract them. The fondness of the male fish for sturgeon spawn has been repeatedly attested.

Prof. John A. Ryder, in his able paper on "The Sturgeons and Sturgeon Industries of the East Coast of the United States," etc.,† shows that the food of the young sturgeons consists chiefly of minute animal forms of great variety; as the fish become more mature, larger organisms, principally worms and crustaceans, are taken, and the full-grown fish often resort to mollusks of considerable size. Summing up his observations, the writer says:

> The story of the life of a sturgeon is therefore seen to be bound up with the lives of vast myriads of organisms in no way related to it in the system, but only as sources of nutriment. It is quite certain from what has preceded that if the minute life upon which the young sturgeons subsist were exterminated, the sturgeon would also become extinct. It follows from this that whatever affects the relative abundance of the minute life of the rivers and estuaries where sturgeons are found must also affect the survival and abundance of the latter. The importance of a study of all the organisms upon which the sturgeon is directly or indirectly dependent must therefore be obvious to everyone. The legitimacy of the inquiries into the life histories of all organisms, even those in no way directly related to the economy of the State, should therefore need no apology from those engaged in the study of the problems of economic fish-culture.

The food value of the sturgeon is yearly becoming more fully appreciated on the lakes as the supply becomes scarcer, and it is only a question of time under existing conditions when the demand for the fish will far exceed the yield of the fishery. The necessity not only of perpetuating but of increasing the abundance of this species in Lake Ontario needs no demonstration. Mention has already been made of the relatively high price commanded by the fish in comparison with other commercial species; but the economic importance of the sturgeon is not only in its flesh, for such valuable secondary products as caviare, glue, isinglass, oil, and fertilizer are made from it, and the skin is capable of being converted into a valuable leather.

The question which presents itself is, How shall the supply of sturgeon in Lake Ontario be preserved? It is suggested (1) that legal restrictions should be placed on

* Report U. S. Fish Commission, part II, 1872–73. † Bulletin U. S. Fish Commission, VIII, 1888.

the capture of immature fish and that the adult individuals should be protected during the spawning season; and (2) that artificial propagation should be resorted to. As to the expediency of enacting more fishery laws for Lake Ontario there may be considerable difference of opinion; but in regard to the desirability of carrying out the second suggestion there can be no doubt, for the feasibility of hatching the lake sturgeon artificially has been fully demonstrated by both the United States and the Michigan fish commissions.

THE ALEWIFE.

This is one of the most interesting species in Lake Ontario, and its occurrence is the cause of the most diversified comment and speculation on the part of fishermen and others. The fish is recognized by fishermen of Lake Ontario under numerous names, which alone are sufficient to exhibit the various ideas which are entertained regarding the presence and identity of the species. The name alewife is naturally the most common and generally distributed one, but in many localities this is unknown. The most numerous designations were heard at Cape Vincent and in the eastern end of the lake, where the names shad, little shad, alewife, mĕnhāden, and mănhăden were indiscriminately used by different fishermen. Both "shad" and "menhaden," in addition to "alewife," were quite frequently heard in other portions of the lake and in the St. Lawrence River. Among some Canadian fishermen of French extraction at Ogdensburg, New York, the name gaspereau was used—a designation applied to the alewife throughout the maritime provinces of Canada—but shad and alewife were the common names in the river. In Monroe County the name sawbelly was in use, and in Niagara County the name moon-eye was heard.

The alewife (*Clupea pseudoharengus*) is a coastal species not indigenous to this lake, and the circumstances of its introduction can probably never be established beyond question. Three principal views are now entertained regarding the origin of the fish in Lake Ontario: (1) That it gained a circuitous entrance into the lake from salt water by means of certain lakes, canals, and rivers in the State of New York; (2) that the fish ascended the St. Lawrence River from the gulf of the same name; and (3) that alewife fry were accidentally introduced with young shad obtained in the Hudson River.

In support of the first view the existence of a continuous water way, other than the St. Lawrence River, between the ocean and Lake Ontario is to be recognized and the possibility of a fish making this transit acknowledged. The writer has no personal acquaintance with the conditions of union of the bodies of water in question, but the maps available indicate numerous routes to the lake by way of the Susquehanna and Hudson rivers and their tributaries; lakes Seneca, Cayuga, Canandaigua, Onondaga, and Oneida, and the Seneca, Oneida, and Oswego rivers, together with the numerous canals which traverse this part of the State.

The existence of alewives in lakes Seneca and Cayuga has been known since 1868, some years before the planting of shad in this region began, and there is little doubt that the fish naturally wandered into these lakes from the ocean, artificial water courses probably being important factors in this extension of the species' range. Both of these lakes have easy communication with Lake Ontario by way of the Seneca River and the Oswego River or Oswego Canal.

The most thorough and scientific inquiry into the presence of the alewife in Lake Ontario has been made by Dr. T. H. Bean, whose studies were published under the title "On the occurrence of the Branch Alewife in certain lakes of New York."* It is unfortunate that this valuable essay could not have received a more general distribution, especially among the fishing interests of the lakes in question, and thus contributed to a proper appreciation of the actual conditions and to a dissipation of some of the erroneous and even absurd views that have become current. Dr. Bean appears to have proved that the fish were first observed in Lake Ontario in 1873, and holds that prior to the introduction of shad fry by the late Mr. Seth Green, of the New York fish commission, they were unknown in those waters. He concludes that the fish owe their existence in Lake Ontario to their accidental introduction with shad, and thinks that the evidence is against their migration up the St. Lawrence River from the Gulf of St. Lawrence, the presence of the fish in the lower river at Montreal being unusual and altogether subsequent to their appearance in large numbers in Lake Ontario and the upper river. He says:

> We are in possession of information which seems to establish conclusively that the alewife does not occur in the lower water of the St. Lawrence River, nor was there any evidence of its presence at Montreal until the past nine years.

Mr. Seth Green, jr., who was associated with his father in fish-cultural work for 20 years, in a conversation with the writer on November 10, 1891, emphatically denied that his father put alewife fry in Lake Ontario and stated that he always disclaimed any responsibility for the presence of this fish in the lake. It seems but proper and just that this statement should be recorded.

It is probably within bounds to say that the alewife is the most abundant fish occurring in Lake Ontario. Schools of great size are often observed at or near the surface; gill nets, pound nets, trap nets, and other forms of apparatus have been known to take large quantities; and thousands of young are caught in small seines to serve as bait in angling for bass, pike, etc. But it is by noting the enormous mortality that the most accurate idea is gained as to the wonderful prolificness of the alewife, the firm hold it has taken in this lake, and the extent to which it has populated the waters.

The alewives of Lake Ontario are remarkable for their small size. On the Atlantic coast the average length of this species is about 11 or 12 inches, but in Lake Ontario no individuals of such large size are seen and the average length is very much less. Among several thousand specimens examined by the writer none were found to be over 7 inches long, and the average was less than 6 inches. This stunting of growth, which is said to be gradually becoming more marked, has no doubt been produced by the unnatural conditions to which the fish are subjected. The extent to which this dwarfing has gone may be readily judged when it is stated that fish only 4 or 5 inches long have been caught with ripe spawn.

The few notes that can be offered concerning the habits and migrations of the alewife in Lake Ontario do not add much, if anything, to the present knowledge of the species. One interesting habit witnessed, which no doubt accounts for the origin of one of the popular names, was the schooling of the fish at the surface in considerable numbers and their "flipping" after the manner of menhaden.

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* The Fisheries and Fishery Industries of the United States. Section 1, Natural History of Aquatic Animals. Washington, 1884.

Regarding the spawning habits, it can be said that in spring the fish are observed to resort to the shallow portions of the lake and also to ascend creeks for the purpose of depositing their eggs. The favorite grounds appear to be around the shores and islands in the eastern end of the lake, the same region which is frequented by the whitefish. A rather important fact that bears upon the question of migration of alewives to and from the Gulf of St. Lawrence is that almost every winter greater or less numbers of the fish are seen through the ice and on the ice banks which form in the lake. The fishermen, as a rule, regard the alewives as permanent inhabitants of these waters and think that the fish retire into the deepest portions of the lake during the cold weather. Fish only 1 or 2 inches long have been seen in March at Oswego and elsewhere. On the other hand, inquiries among fishermen and others at Ogdensburg elicited information tending to show that at that point at least there is a well-marked migration up the river toward Lake Ontario in June and down the stream in the fall. The fish are caught in considerable numbers in nets along the Canadian shore, and in many places are peddled through the country and sold for food. The greatest quantities are taken below the rapids, where the fish always appear to be more numerous than elsewhere in the river.

Mr. Charles H. Strowger, of Nine-Mile Point, Monroe County, New York, communicates some interesting observations on the spawning condition of alewives examined by him at that place in the spring of 1892. He says:

> The ice did not leave the shore at Nine-Mile Point until the first week in April. A few full-grown alewives were cast ashore together with a number of small ones ranging from 1¼ to 2¼ inches in length. This was on April 9. The fish were fat and apparently healthy, and about half of the full-grown ones had spawn matured; no males noticed. April 17—Picked up fifteen grown alewives on the beach varying from 5¼ to 6¼ inches in length from the nose to the insertion of the tail fin. Several small ones were also present. They were fat, with no signs of disease visible. The spawn in the females was ripe except in one instance, and in most of them the spawn was running. Two were males, but in neither of them was the milt mature. April 18—Took from a gill net with 1¼-inch mesh sixteen live alewives, largest 8¼ inches long, more only 6 inches long. Of these, nine had spawn running, five were immature, and two were males with milt not ripe. These fish were all in fine condition, with flesh plump and firm. April 28—Have caught only yellow perch since the 18th until this morning, when I took up a single alewife. Its spawn was running. Since the yellow perch has appeared here (to spawn) the alewife has left the shore.
>
> Owing to the new fish laws of this State, it will be difficult to make a very thorough study of our shore fish, as the law now prohibits netting within a mile of the shore. What few fish I have examined give me the impression that alewives spawn rather earlier than perch.

Viewed from the economic standpoint, the alewife is no doubt a more important fish than is generally believed among the fishing interests and should not be regarded as altogether a pest. Used as bait in the trawl-line fishery for sturgeon and trout it is a valuable fish and takes the place of other fish that are of more importance as food species, notably young ciscoes and suckers. The young also constitute a prominent bait in the sport fishing which is so extensive on this lake.

When washed up on the shores, or when caught and treated like menhaden, they form a valuable fertilizer, and many tons are utilized annually by the farmers living adjacent to the lake; although it should be said that in most localities the washing ashore of dead alewives is not favorably regarded, and unless measures are taken to bury or haul off the fish they become public nuisances. At one time a small factory was operated in the eastern end of the lake for the purpose of utilizing the abundant

alewives in the manufacture of oil and guano; this was soon closed, however, owing partly to opposition to the use of the pound nets and partly to the growing deficiency of oil in the fish.

Perhaps the most valuable purpose which alewives subserve in this region is that of supplying food for other fish. In their defenseless condition they fall a ready prey to bass, pike, pike perch, muskellunge, perch, trout, ciscoes, and other species, and in this way become really important factors in the growth and multiplication of other fish. Black bass eat alewives in large quantities, and when the former first arrive in the inshore waters in the spring they are almost invariably found filled with alewives. In certain places, but more especially at Oswego, both bass and pike perch have increased greatly since the alewives became abundant. Wall-eyed pike are reported to be particularly fond of alewives, and "pickerel" (*Esox*) also feed on them to a considerable extent. At Oswego, New York, on August 19, a whole alewife, over half the length of its captor, was found in the stomach of a small pickerel.

The value of the lake alewife as food for man should not be overlooked. Although of small size and bony, it is not without its champions among the lake fishermen, and it is occasionally eaten. It has no commercial value, however, at present, and will probably never be in demand as a fresh article of food; but the writer believes that it can be made to take a prominent place among the economic lake species if put on the market in a smoked condition. The alewife is similar in size to the sea herring so extensively used on the New England coast in preparing the most popular brands of smoked herring, and there does not seem to be any objection to its utilization in this way.

The method of preparing the small sea herring on the coast of Maine is entirely applicable to the lake alewife and is, briefly, as follows: The fish, as taken from the water, are closely strung through their mouths and gills on smooth sticks about a yard in length, after which they are immersed in a solution of common salt for the purpose of hardening and preserving them and of removing the scales; they are then suspended in the smokehouse, where they are left until cured and well colored, and are afterwards arranged crosswise in boxes to the number of 50 to 75, when they are ready for sale. The boxes are made of soft wood and are quite inexpensive. The usual dimensions are 15 inches long, 7½ inches wide, and 4 inches deep. Such a box holds about 5 pounds of smoked fish. The best prepared "cross" herring usually have a ready market at from 15 to 20 cents a box, and the lake alewife would no doubt prove a satisfactory substitute and yield as good returns.

One of the most interesting phases in the history of the alewives in Lake Ontario is the enormous mortality to which they are subject. This fact more than any other has brought the fish into prominence and during the past few years has called forth voluminous newspaper correspondence and comment. The mortality occurs chiefly during warm weather, especially during June and July. When the wind is favorable the fish will be washed up along the entire southern shore of the lake, at times being piled up to the depth of a foot or more in certain places. Large areas of the lake bottom have also been found to be thickly covered with dead fish.

The decomposition of the fish washed ashore has proved a nuisance in almost every community on the lake. People have in certain instances been obliged to leave their homes, owing to the unbearable odor arising from the putrefying fish. Tons of dead fish have been annually hauled away to be used on land as fertilizer or buried

to prevent noxious odors. In some sections the town authorities have been obliged to come to the aid of the inhabitants and have the fish disposed of at public expense. This was the case in Wilson, New York, where, in 1891, about $300 was expended in ridding the shores of the town of decaying fish. In a small slip, about 30 feet wide, at Sacketts Harbor, New York, in June, 1891, three wagon loads of dead alewives were hauled off the shore in one day. This was after a strong blow from the north. At the same place, on August 15, 1891, several thousand were seen on a small point that enters into the formation of the harbor. They were all dry, and not putrefying; and were of small size and exceedingly thin.

The contamination of the water adjacent to large bodies of dead fish on the bottom must exert a harmful influence on the presence and abundance of desirable food-fish. The absence of whitefish and trout from the American shores is by many fishermen attributed entirely to this cause.

In attempting to account for the death of the alewives it should be stated at the outset that no scientific investigation of the subject has ever been made, although it would seem to be a most inviting field for research. The question is of no little economic importance from several points of view, and it seems somewhat remarkable that during the two decades in which the fish have been dying in such enormous numbers no systematic study of the conditions of their life and death has been undertaken.

Among the causes which have been suggested as leading to the death of the alewives, the following may be mentioned:

(1) *Fungous disease.*—Fishermen living at various places on the lake have at times noticed moldy spots on many dead fish that have been washed ashore. Some alewives still alive have also been seen suffering with this condition. The fungus has been observed to be usually on an ulcerated or abraded area.

A correspondent of the Rochester Post-Express, writing on this subject in the issue of that paper for October 28, 1891, says that as soon as the ice moves out of the lake in spring the fish approach the shores and the mouths of rivers, and that at this time they are healthy and fat. He continues as follows:

> But as soon as the water grows warm the fish are attacked by a white fungoid parasite, which soon covers large spots on the fish, looking like short, fine, white hair or fur. Sometimes it will envelop the whole fish, but more frequently only a spot on a fish will appear, from the size of a speck to that of a quarter of a dollar or larger. The consequence of this attack is seen in the establishment of curious ulcers, which soon destroy the fish. This white pilose parasite (whether animal or vegetable) is carried by these fish into the bays and impregnates the water so that it is almost impossible to confine minnows for bait in such localities. Not being in possession of a good microscope I have not attempted to investigate the nature of the parasite I mention, but it is certain that it is the slayer of millions of alewives.

This gentleman speaks from personal observation and his remarks are entitled to consideration. The villous parasite which he mentions is quite common on fish kept in captivity and has recently appeared among the trout at the Caledonia hatchery of the New York fish commission. It is probable that the fungous growth attacks fish whose general vitality is lowered by other causes, and it is not definitely known that it ever appears on perfectly healthy fish or on an unabraded surface.

(2) *Deficient food.*—Hon. Marshall McDonald, U. S. Commissioner of Fish and Fisheries, whose great familiarity with the clupeoids is well known, thinks that insufficient food may play an important part in the mortality observed among the alewives in Lake Ontario. The fish multiply rapidly, a single female laying as many as 60,000

eggs each season, and it is thought that the minute organisms which form the principal part of the food of such fish may not grow sufficiently rapidly or abundantly to supply the countless millions of alewives (in addition to other fishes with similar food habits) which are restricted to this body of water year after year.

Lack of food must no doubt be the principal if not the only cause of the excessive leanness which is universally recognized and commented on by fishermen, many of whom state that a fat alewive is now rarely seen, although during the earlier years the fish were quite oily.

Prof. Charles S. Dolley, of the University of Pennsylvania, in an article in the Rochester Post-Express of August 8, 1891, says:

> The probable reason for the death of such large numbers of fish is that they have the habit of abstaining from food during the breeding season, and thousands undoubtedly succumb to the fatigues of a long swim from the sea against the current of the St. Lawrence. and in their subsequent search for suitable spawning-grounds.

This view is contrary to the observations of Mr. Strowger (page 189) and is strongly antagonized by an anonymous writer in the issue of the same paper for October 28, 1891, who says:

> That the professor was entirely without information on the subject may readily be seen from the fact that it is not in the spawning season that the mortality occurs. I doubt if any person ever saw eggs in a dead alewife in the latter part of May or June and beginning of July, in which this mortality occurs. They do not die at the spawning season, and they do not perish from fatigue in ascending the St. Lawrence River. The alewife, or sawbelly, is always present in Lake Ontario, and * * * as a whole does not migrate, although it is not at all improbable that millions of them descend the St. Lawrence to the sea in the autumn.*

(3) *Storms.*—Every heavy storm during the warmer months is accompanied by the washing ashore of greater or less quantities of alewives, and the fishermen in some localities have come to regard disturbances of the elements as the most potent factors in causing the death of the fish. It is held that the fish are partial to shoals in the lake and shallow places near the shore, and that when overtaken there by storms they are easily destroyed by the violence of the wind and water. This theory is hardly tenable for several reasons, chief among which is that no such mortality is observed in other fish that are also known to resort to shoals for feeding and spawning.

(4) *Temperature of water.*—The apparent prevalence of the epidemic only during the warmer months has induced many fishermen to look upon the elevation of the water temperature as the cause of the death of the fish. The highest temperature would naturally be found on the shoals, which, as has been stated, are favorite resorts of the alewives.

Mr. S. Wilmot, superintendent of fish-culture for the Dominion of Canada, is quoted as favoring this theory: "He attributes the heavy mortality to the higher temperature of the lake water in summer time as compared with the ocean, and particularly to the fact that these fish seek the shallow and consequently warmer water to spawn, and in this way are killed off by thousands."† This idea is favorably entertained at Wilson, New York, and other places towards the western end of the lake.

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* See Forest and Stream, September 10, 1891, for further discussion of this question.

† Ogdensburg Journal.

THE SHAD.

In a learned paper on the shad (*Clupea sapidissima*) in the Annual Report of the Commissioner of Fish and Fisheries for 1872–73, Prof. Baird considers the question of the naturalization of shad in inland waters, and says:

The problem as to the possibility of naturalizing the shad in the Great Lakes, so that they may subsist there the greater part of the year and find a supply of food, is more difficult of solution, and one that can only be decided by experiment. We have, however, the interesting fact that the deep waters of the Great Lakes abound in certain species of minute crustaceans, precisely similar to those occurring on the Atlantic coast, and which, while consumed to a great extent by the whitefish, may be presumed to be in sufficient surplus to feed an indefinite number of shad. The experiment of stocking the lakes with shad has been already made by Seth Green, who planted 15,000 in the Genesee River near Rochester, in 1871. A number of these were subsequently taken in nets, and it is thought probable that the spring of 1874 will witness the movement of mature fish up the Genesee River.

Concerning the same deposit of shad fry to which Prof. Baird refers, the New York fish commissioners say:

This was purely an experiment to test the question whether these fish, which, according to their natural habits, seek the salt water every winter, would live and thrive either in the fresh water of the river or by passing from it into a fresh-water lake. It was not considered probable that any of them would be able to descend the St. Lawrence to the sea and reascend, escaping all the implements of destruction in their route, so as to reappear in this river. But experiments which had been made with the salmon on the northern shore of Lake Ontario had given credence to the impression that it is possible for migratory fish to live in streams which connect with any large body of water, whether fresh or salt. This impression has been in a measure confirmed by the result; for, in the month of June, 1872, young shad were caught near the mouth of the Genesee, 5 or 6 inches in length. Two months later shad weighing a quarter of a pound and 7 inches in length were taken in Lake Ontario, within 5 miles of the mouth of the Genesee. As many as 100 of these were caught at a time in a small net, so that the conclusion may be regarded as established that shad will live and thrive under such circumstances, although whether they will attain the size and the age that they reach in the rivers running to the ocean, or whether they will breed, are questions yet to be settled. In order to make the experiment more thorough and to give it a better chance of success other rivers were stocked in the same way. Sixty thousand additional young shad were turned loose in the Genesee on the 21st day of June, 1872. On the 25th 30,000 were placed in Lake Onondaga. (Report of New York fish commission, 1872.)

The initial plants of shad fry in 1870 and 1871 were followed in the two succeeding years by larger deposits, and, after an interval of three years, by still more numerous plants in 1877 and 1878. The total number of shad fry deposited each year in the streams entering Lake Ontario and in the smaller lakes connected therewith is shown in the following table. The plants were all made by Mr. Seth Green, under direction of the New York fish commission.

Years.	Genesee and Black rivers.	Lakes Onondaga, Canandaigua, and Cayuga.	Total.
1870	5,000	.....	5,000
1871	15,000	.....	15,000
1872	60,000	30,000	90,000
1873	70,000	108,000	178,000
1877	80,000	.....	80,000
1878	290,000	.....	290,000
Total	520,000	138,000	658,000

As noted by Prof. Baird, the appearance of adult shad promptly followed the introduction of young fish into the Genesee River, and from that time on for a number of years the indications pointed to the probably successful acclimatization of the species. Since about 1885, however, the fish have appeared to be growing scarcer, and their final disappearance seems to be only a question of a few years.

Prior to this experimental introduction shad were unknown in Lake Ontario, and the theory that their presence was due to their migration up the St. Lawrence River is considered untenable by those who have given the subject sufficient study.

The shad appear to have distributed themselves over the entire lake. At almost every fishing community on the American shores of the lake the fishermen remember to have taken at irregular intervals between 1875 and 1885 the fish, which was at first a stranger to them and which they now seldom, if ever, see. Reports from the northern shore of the lake indicate that the shad were probably fully as numerous there as on the southern side. The greatest numbers seem to have been taken in the eastern end of the lake, in the vicinity of Cape Vincent, in Chaumont Bay, and around the islands, where the principal trap fisheries have been prosecuted. Prior to 1888 several hundred adult shad were caught each year in this region, but of late the American fishermen have seen none whatever, and the few fish secured of which any record could be obtained have all been caught in Canadian waters. About August 6, 1891, Mr. W. Ainsworth, of Cape Vincent, received a shad from Canada, this being the only one seen during the year. In 1890 he handled a fine specimen, also from Canada, weighing 5 or 6 pounds and about ready to spawn.

A suggestion as to the cause of the disappearance of shad in the waters of the lake is that the fish went to salt water down the St. Lawrence River and failed to return. They have been repeatedly seen in the river, and one of the most interesting observations of their habits was made at Thousand Island Park. In August, 1881, Mr. H. L. Matheson, of Oswego, New York, was fishing at that place for black bass. As an experiment he baited his hook with a grasshopper and cast his line from the shore of the island into the current, made somewhat muddy by a strong westerly wind. The bait was promptly taken, and to his great surprise a 3-pound shad was landed. More grasshoppers were secured, and fifteen shad, weighing from 2½ to 3 pounds, were taken in a few hours. On succeeding days six, three, and two fish, respectively, were caught. Several other parties took one or two fish each in the same way.

While it is possible that some of the fish left the lake by way of the St. Lawrence River, the most plausible reason for their disappearance seems to be that of the necessarily small proportion of the original plants which reached maturity nearly all were caught before natural reproduction supervened. It is also probable that the great multiplication of alewives unfavorably affected the increase of shad by diminishing the food supply.

The fact that shad were taken in Lake Ontario in 1891, thirteen years after the last fry were deposited, may be taken as a sufficient indication that the waters of the lake are adapted to this species, although it does not necessarily prove that the continued introduction of young shad would eventually result in the production of sufficient numbers of fish suitable for food to serve as the objects of a special fishery or to offset, in point of value, the original outlay. At the same time it must be apparent that the plants of shad in the tributaries of Lake Ontario were wholly inadequate to stock such a large body of water; and it is unfortunate that the experiments should have

been discontinued at the very time when most important results were beginning to be manifested. To illustrate the apparent inadequacy of the measures taken to produce an abundant supply of shad in the lake, it need only be remarked that the average number of fry annually deposited was equivalent to only 17 fish to the square mile of lake surface, and that the entire plants during a period of six years represented less than $\frac{1}{100}$ of the quantity of fry that has been devoted to a single coast basin in a single season. It is estimated that probably 10,000 or 12,000 more or less mature shad have been taken in Lake Ontario. This is assuredly a satisfactory experiment, and strongly argues for the resumption of shad-culture in the lake.

THE ATLANTIC SALMON.

The Atlantic or salt-water salmon (*Salmo salar*) was at one time an exceedingly abundant fish in Lake Ontario and its tributary streams; to-day it occurs only as a straggler, a curiosity to the young and a relic of other days to the aged inhabitants of the region. The practical disappearance of salmon from the lake is another of those almost phenomenal changes which have occurred in the fisheries of Lake Ontario, but the comparison of the past and present abundance of salmon is much more striking than in the case of the trout and whitefish. The history of the salmon in this body of water is a forcible illustration of what may be expected to take place in all inland waters when the destruction of fish by man is not mitigated or counterbalanced by resort to artificial propagation of adequate scope, supplemented in the case of certain species by protection and encouragement during the important period of reproduction.

The narration of the previous abundance of the salmon in Lake Ontario and its tributary streams reads like a romance, and the possibility of reëstablishing a good run of salmon in Lake Ontario and of restocking its waters with this valuable food-fish opens up one of the most important, interesting, and inviting fields connected with the present fishery agitation in this region, making a thorough inquiry into the past and present conditions very desirable. The accounts of the early abundance of salmon indicate that the fish at certain times ascended nearly every stream on both the American and Canadian shores, chief among which were the Salmon River, Little Salmon River, Black River, Big Sandy Creek, and Oswego River on the southern side, and Wilmot Creek in Canada, the first named being the most famous. The cause which led to the ascent of the streams was the same which now operates in the coast rivers in which salmon occur, namely, the reproductive instinct. The fish approached the shores in June and, if the water was sufficiently high, went up the streams to their head waters, deposited their spawn, and returned again to the lake. There are also numerous authentic records of another fluvial migration for the same purpose later in the year, usually in September, a circumstance which led some of the fishermen to believe in the existence of two kinds of salmon in the lake,* which were distinguished as spring spawners and fall spawners.

There was an advent of salmon in the Oswego River which was called the "June run." This was usually two or three weeks earlier than the appearance of fish in the Salmon River. The inland lakes in which the Oswego rises kept that river well filled most of the time, but the Salmon River was ordinarily low when the salmon first came on the shore.

* See paper by Dr. Edwards (hereafter quoted) and testimony of B. E. Ingersoll and John S. Wilson.

The question as to whether, after spawning, the salmon returned to the sea, after the manner of the fish in the coastal streams, or simply retired to the deeper portions of the lake, naturally comes up for consideration. The weight of the testimony and evidence seems to indicate that the salmon had, possibly during a long period of years, become acclimated in the waters of the lake and ceased to require salt water, although it is not improbable that certain individuals annually made their way down the St. Lawrence River to the large tributary of the sea at the mouth of that stream. In a discussion of the salmon of Lake Ontario, participated in by Prof. Baird, Mr. Seth Green, and others, an abstract of which is given elsewhere, this subject is further considered.

The usual range in the weight of the salmon caught during the period of their abundance was from 7 to 40 pounds, individuals of the latter size being uncommon; the average weight was probably about 10 pounds. Mr. B. E. Ingersoll, now of Oswego, New York, informs me that his father killed a fish in Salmon River that weighed 42 pounds.

From a mass of notes and correspondence from fishermen and others concerning the former occurrence of salmon in Lake Ontario, a few extracts are here presented which are thought to add to the published knowledge of the history of salmon in that region.

Mr. B. E. Ingersoll has furnished some interesting statements concerning the former occurrence of salmon in the Salmon and Oswego rivers. Writing of the former stream he states that fifty or sixty years ago the river was well supplied with salmon. He was born and lived within 100 rods of the river until 16 years of age. His grandfather was the second man to settle in the town of Richland, and his father was brought to the region at the age of 2 years. The abundance of salmon seems to have been a very important factor in the settlement of the region; the salmon were all the settlers had to depend on for ready money, and constituted a valuable and easily accessible food. About fifty years ago his father and a Mr. Arthur Matheson, while fishing from a boat with jacklight and spear, caught 601 salmon in a single night.

Mr. Ingersoll has heard his father relate the circumstances of a visit to the Oswego River to spear salmon. He had his log cabin on the shore of the river on the present site of the Doolittle House. At that time there was only one store in Oswego, which was situated on what is now the corner of West First and Cayuga streets. The elder Ingersoll entered into a contract with the proprietor of the store by which the latter was to take all the salmon caught during the two weeks' sojourn on the river at the uniform rate of 2 cents a pound. For about a week only from 25 to 50 fish were speared each night, and the storekeeper during that time continually importuned Ingersoll to catch more fish. Another school of fish then struck on and from 300 to 400 were taken each night. This was more than the dealer could handle, and he paid $50 for the privilege of suspending the contract.

It was nothing uncommon for teams fording the rivers and creeks at night to kill salmon with their hoofs. An old settler living in the town of Hannibal told Mr. Ingersoll that one night while driving across Three-Mile Creek the salmon ran against his horses' feet in such numbers that the horses took fright and plunged through the water, killing one large salmon outright and injuring two others so that they were captured. The farmers living near the smaller creeks easily supplied their families with salmon caught by means of pitchforks.

The salting of salmon for trade and winter consumption was largely engaged in by farmers and others. On the Salmon River the fish were salted in the fall and many were peddled through the country during the winter. One barrel of salt salmon was then equivalent in value to two barrels of salt. Salmon were so plentiful that men hiring out to work stipulated that salmon should be given them to eat not more than three days in a week, and in binding out apprentices the same agreement was made.

On the Salmon River the people who owned the land controlled the riparian privileges connected therewith. The owners often combined, and as much as 2 miles of shore were operated by some companies.

During the spawning season, fishing was permitted only on every other night, and about half the run was thus allowed to pass up unmolested. Fishing at that time was principally with spears, 90 per cent of the fish being caught in that way. A few weirs were sometimes built, usually between an island and the mainland. When a school was seen adjacent to the weir, two or three boats were launched and the fish frightened or driven into the weir, which was often completely filled. There seems to have been considerable opposition to the use of weirs; rival fishermen often tore out the weirs of their neighbors, and the existence of a weir intact was only secured by vigilance day and night; and even among those who operated weirs they were not very popular, as a great many small fish were sacrificed for which there was no use. After the fish began to grow scarce, the use of weirs was entirely discontinued.

Mr. John S. Wilson, of Wilson, New York, at the mouth of Twelve-Mile Creek, reports that about twelve years ago two salmon weighing 1½ pounds each were caught there, and none has since been seen; at one time they were plentiful in that vicinity. They came to the shores in spring, ascended the creeks, spawned, and then went back to the deep water of the lake where they remained until the following spring and where they were sometimes taken in gill nets, although the principal means of capture was the spear, used when the fish were in the streams. In the fall there was another run in the creeks made up of fish that had not entered in the spring.

Mr. W. E. Nelson, of Port Ontario, New York, writes that 40 or 50 years ago salmon were very numerous in the lake and in Salmon River. They were netted and speared in great numbers in the river. The fish were of good size, often weighing as much as 40 pounds. Since that time they have gradually decreased, and the last of which he has heard were caught in the lake at Port Ontario about three years ago. They were small fish weighing only 2 or 3 pounds. He further states that, although there are dams in the Salmon River, near Pulaski, with proper fishways this river (which was in former days the most famous salmon stream flowing into Lake Ontario) would be accessible for a distance of over 12 miles from its mouth.

Mr. Charles Learned, of Sandy Creek, Oswego County, who has been a fisherman for thirty years, writes as follows regarding the salmon in that vicinity:

> I have not seen a salmon in this part of the lake in about ten years. Twelve or fourteen years ago the salmon were quite plenty. I caught eleven in one day in a seine. Thirty years ago they were taken in trap nets. I never caught one that weighed more than 20 pounds. About fifteen or twenty years ago some young salmon were put in Salmon River, and the fish were quite numerous for three or four years. I think that Salmon River is suitable for salmon to run up to spawn. The conditions are as favorable as they were fifty years ago, and on some smaller streams more favorable, for the sawmills have shut down and the dams are gone. On Salmon River it is 4 miles to Pulaski, where there are two dams; on Little Sandy it is 5 miles to the first dam; but the country is being cleared up so that there is not so much water as formerly in the streams in the latter part of the season.

Writing of the former occurrence of salmon in Chaumont Bay, Mr. Earl S. Douglass says that it has been at least ten years since he saw any salmon in that vicinity. The fish never inhabited that section of the lake to such an extent as they did the portion adjacent to Oswego and Port Ontario. Regarding the availability of the rivers, he thinks that the conditions are not as favorable for the ascent of fish as they were during the period of their abundance, and that some of the streams in that vicinity which the fish formerly frequented are now mostly dry, at least during a portion of the year. The few fish which he remembers to have been caught in Chaumont Bay were taken in a pound net and weighed about 10 pounds.

Mr. E. B. Horton, of Henderson Harbor, Jefferson County, New York, says that he has not caught a salmon in that vicinity for twelve or thirteen years, and knows of only one being taken in that time. This was taken in Stony Creek, with a whitefish gill net having a mesh of 2¼ inches, and weighed 6¼ pounds. The only stream in that immediate vicinity is the Black River, which he does not think would be adapted for salmon, as the water is contaminated by refuse from paper mills situated not far from its mouth, and the acid used is said to kill pike, bass, and other fish, and would prove equally injurious to salmon.

At a conference of fish commissioners held in New York City October 19, 1872, the subject of salmon in Lake Ontario was one of the principal questions discussed.* Many important points having a bearing on the present agitation were brought out, and it is thought advisable to introduce the following abstract of the proceedings:

Prof. Baird, in speaking of the migrations of the salmon, stated that it had not been determined whether the Ontario salmon went to the ocean and returned to the lake again each year. Dr. Edmunds, whose observations are given in full elsewhere, said that some of the fishermen made a distinction between the salmon of the lake and what they called the Bay Chaleur salmon, but he did not know in what respect they differed from each other. Mr. Seth Green remarked that a good many salmon still ran up to the head of Lake Ontario and up Wilmot Creek, which is only 10 or 12 miles in length. He did not regard these as landlocked salmon, though they may never go down the St. Lawrence, and thought the fish might find suitable food in the lake. Mr. Thaddeus Norris was an old salmon-fisher, and had given considerable attention to the habits and instincts of the salmon. He thought the salmon that Mr. Wilmot, of Canada, procured were fresh-water fish, and that the salmon of Lake Ontario had lost their sea-going instinct; Lake Ontario was their wintering-place; they live there all the year when not going up the rivers to spawn. Mr. Norris thought that the salmon of Lake Ontario were fresh-water salmon, for the reason that they had minnows in them, the habit of salt-water salmon being to abstain from food when ascending the rivers to spawn. Mr. Seth Green gave his experience as a fisherman and fish-dealer for many years on Lake Ontario. In the course of his operations he had dressed tons of salmon, but had failed to find food in their stomachs. The fish were taken in trap nets in the lake, set along the shores, and he thought the trap nets had practically exterminated the salmon in Lake Ontario during a period of five years.

Prof. Baird, speaking concerning the introduction of salt-water salmon into the lakes, said he had full confidence that the experiment with the Penobscot salmon would be successful. It was well known that the principal food of the salmon in the

*See Report U. S. Fish Commission, 1872–73, p. 788.

North Atlantic consists of small shrimps, about half an inch long, mostly belonging to the genus *Mysis*. Investigations recently made in the deep waters of lakes Superior and Michigan had disclosed the existence of the same shrimp at a depth below 25 fathoms, where it constitutes, to a great extent, the food of the whitefish. The professor called attention to the fact that the gastric juice of fish acts after their death and this accounts for finding so little in stomachs of fishes which feed on small, soft organisms, unless examined immediately after being caught. After a few hours, only a microscopic examination would demonstrate on what a fish feeds. The occurrence of this small shrimp in the larger lakes is the guaranty that salmon will thrive there, and when the fish descend the rivers to the lakes they are practically in the ocean.

In an important article on obstructions to the ascent of fish in rivers, printed in the Report of the U. S. Commissioner of Fish and Fisheries for 1872–73, Dr. M. C. Edmunds, of Vermont, recounts his observations in the St. Lawrence Basin, undertaken at the request of the late Prof. Baird, in 1872. This inquiry, although made twenty years ago, may appropriately be alluded to in this connection, since it covered Lake Ontario and related to the causes which had operated to render the salmon a rare species in the lake fisheries even at that time. The investigation included an examination of all the streams on the southern shore of the lake formerly frequented by salmon. That portion of the paper pertaining to Lake Ontario is here quoted in full:

The salmon formerly were very plenty along the southeast shore of the St. Lawrence, inhabiting the lower reaches of the Chateaugay, St. Regis, Racquet, and Grass rivers, emptying into the St. Lawrence within the Canadian Dominion, as also the Oswegatchie in the State of New York. Of these streams I took but little notice, but passed on to the inspection of the rivers immediately debouching into Lake Ontario proper. Of these, first in order I inspected the Black River and Chaumont, both of which I found to have been formerly inhabited by the salmon. Neither of these rivers at the present time offers any inducements for the introduction of the salmon by reason of high and impassable dams. Both of these streams at their outlets into the lake are susceptible of being made quite profitable fields for salmon-breeding could the trap weirs and pound nets be permanently excluded; but these are so plenty and the fishermen so lawless that it would be useless to begin any experiments here.

My attention was directed to the Big Sandy Creek and Salmon River, in Oswego County. The former of these ceased long ago to be a salmon stream and received but slight notice at my hands, while the latter claimed my *special* attention, being the first river which I have yet found in all my travels in which the salmon are now found. I inspected the river several miles from its mouth upward and found it all the way admirably adapted to the growth of salmon. There are several dams situated on the river, but so low and in such favorable localities as to give easy passage to the salmon. I found, on inquiry, the fact that several salmon were caught below and above the dams last fall, and that several were caught below the dams early the past summer. I think this, above all streams heretofore seen, to be the best calculated to commence the breeding of salmon artificially. It is quite evident that they ascend the river above the dams, and when above have a wide range and are free from the attacks of all predatory fish. An establishment might be built upon some favored locality above the dams where the process of artificial propagation could be begun and successfully prosecuted. I noticed several streams where such an institution might be begun, and where as favorable results could be effected as those attending the experiments of Wilmot at Newcastle, Ontario. There are no trap weirs or pound nets, as I am informed, in the mouth of the river to prevent the salmon from entering the same with safety. The people in this locality are all kindly disposed to aid and assist this project and are quite anxious that experiments should be commenced here.

After leaving this river I took up next in order of inspection the Oswego. This river has its source in the interior lakes of central New York. It was also once a very noted salmon stream, and salmon ascended into the Cayuga and Seneca lakes; but the canal, which extends from Oswego to Syracuse, follows nearly the whole course of this river, debouching into it, thus making it unfit for a

BAIT FISHES.

With a view to protect the game fish, laws have been enacted in New York restricting the means of capture to hook and line in the St. Lawrence River and within a certain distance of the shore in Lake Ontario. The use of small-meshed seines to supply bait minnows for angling is permitted, and enormous quantities of minnows are thus annually consumed. In the river and at the numerous fishing resorts on the lake more than 100 men and boys give more or less exclusive attention to seining minnows during the angling season, and generally secure handsome returns, the ruling prices for minnows being from ½ cent to 2 cents each.

The yearly drain on the minnows is not without its results, especially in the St. Lawrence River, where the supply is said to have been much diminished in 1891, and minnow fishermen in the vicinity of Alexandria Bay were often obliged to go in their boats a distance of 20 miles to Lake Ontario to find sufficient quantities of small fish, although at one time all the bait consumed in the river was caught locally.

Careful estimates, based on information furnished by bait-dealers and others, show the number of minnows caught for bait in 1891 in Lake Ontario and its tributaries and in the St. Lawrence River to have been not less than 9,000,000, including those which died before being used and were thus sacrificed. The mortality is very large.

Besides the minnows, so called, used for bait, considerable destruction of immature fish occurs. Young fish of almost every species are naturally taken in the seines, and are classed as "minnows" or "bait" by the dealers. Unfortunately, small whitefish are not exempt, and in the vicinity of Fox Island, where whitefish formerly spawned in great numbers and where the young now appear to congregate at times, considerable quantities are sometimes taken for bait; these are from 1½ to 3 inches long. Small trout, bass, pike, and herring are also used whenever they happen to be taken.

This matter is not without its practical bearing on the question of food and food supply of the piscivorous fishes and the following list of bait minnows is offered as a fragmentary contribution to the subject. The species mentioned were obtained from bait fishermen in various localities on the southern shore of Lake Ontario. The list could of course be greatly extended by a special investigation; as it stands, it simply represents the personal observations incidentally made by the writer. The local names applied to the fish, so far as heard, are given in quotation marks.

1. **Catostomus teres** (Mitchill). *Common sucker; "Mullet."*

This is a well-known fish in Lake Ontario, and is often used for food. It attains a length of 18 inches. When of small size it is frequently employed as a bait. Six specimens, about 1¾ inches in length, were obtained from minnow fishermen.

2. **Campostoma anomalum** (Rafinesque). *Stone-roller; Stone-lugger.*

Four specimens of this interesting species were preserved, the largest of which was 2⅜ inches, the smallest 1¼ inches. These differ much in color from more mature examples. The upper parts are of a dark-brownish color, with faint mottlings; the under parts are white. A blackish lateral band about width of eye extends the entire length of body and appears as a bar on the snout; above the dark band is a narrower light one.

It may be stated that the catching of salmon *per se* was not the cause of their decrease, which was due to the prevention of their ascent of the streams in sufficient numbers to secure the perpetuation of the species.

The practical questions to which the preceding discussion leads are:

1. Can the return of salmon to Lake Ontario be accomplished?
2. Are the conditions sufficiently favorable to warrant the attempt?
3. How is the reëstablishment of the salmon fishery to be brought about, and what steps would be necessary to secure the best and most immediate results?
4. Will it be possible to obtain a sufficient abundance of salmon to permit the prosecution of commercial fishing, and will the value of the fishery to the State be a profitable return for the original outlay?

The first question can be promptly answered in the words of the United States Fish Commissioner in his report to the Senate, to which reference has already been made: "It is not only possible, it is entirely practical, to restore and maintain these fisheries by adequate recourse to means and agencies entirely within our control."

The present conditions in most if not all the streams are certainly not such as to invite efforts to secure a return of salmon to them. Refuse and insurmountable dams are still present. A very important consideration, also, is the change in the topography of certain regions due to the clearing up of swamps and the cutting away of forests, by which the water supply of some streams has been materially affected.

Mr. B. E. Ingersoll thinks the fishery for salmon can not be reëstablished in the Oswego River, as it is so filthy with sewage and refuse from manufactories that the salmon will not go up it. It is thought, however, that they might ascend the Salmon River, as that is less filthy than the Oswego River, and beyond Pulaski, where the manufactories are located, the water is of good quality, although it is open to the further objection that the river gets very low, especially in dry weather, and rises and falls very rapidly after rains, because the swamps that formerly acted as reservoirs for the surface water are being gradually cleared up.

The initial steps in an attempt to obtain a return of salmon would include an examination of the streams in order to determine the character of the water, the number and nature of obstructions, and the extent of the contamination of the water by refuse from manufactories, sewers, etc. This should be followed by the removal of unnecessary obstructions and the building of fishways in such dams as were required for the prosecution of important business enterprises. Provision should be made for other disposal of mill and city refuse. Protection of salmon for a term of years should be secured. Coöperation between Canada and this country should exist from the outset, as Canada has streams as well adapted to salmon as any in New York and would no doubt profit by work done on the southern shore of the lake. Uniform regulation of the lake fisheries by the two nations would be necessary, but this can not now be secured, owing to the exclusive jurisdiction of New York over the American portion of the lake. The Canadian members at the international fishery conferences held in November and December, 1891, in New York, Rochester, and Hamilton (Ontario), expressed the hope that the Imperial Government would cede to the provinces the control of the inland waters; but even if this privilege were granted, no agreement between New York and Ontario affecting the lake fisheries would be binding on either party, and protective laws would be subject to repeal at any time, and the work of restocking the lake with salmon (and other fish) would be in constant jeopardy. The

assumption by the United States of the control of the fisheries of international waters, as is already the case with navigation, would permit the conclusion of a treaty with Great Britain by which alone could adequate protection be assured.

Having arranged the foregoing preliminaries, the important work of artificially propagating salmon could be undertaken with every prospect of success. The Maine hatching stations of the U. S. Fish Commission could furnish an abundance of salmon ova for the first few years, after which the supply could be drawn from Lake Ontario, in the opinion of United States Fish Commissioner McDonald. He also thinks that generous plants of yearling fish in the head waters of the rivers formerly frequented by the salmon will accomplish more than the simple deposit of fry in these waters or in the lake. The employment of the young of the land-locked variety of salmon would be an important feature of the work of rejuvenating this fishery, for it is probable that the instinct to migrate to salt water would in this fish be lost and the constant presence of salmon in the lake basin would be secured. To sum up this subject in the words of Commissioner McDonald:

> The regeneration of the fisheries must be accomplished through fish-cultural work, systematically and persistently pursued. Their maintenance must be assured by the concurrent regulation of the lake fisheries by the United States and Canada and by the enforcement on the part of the State of New York of such regulations and requirements as will permit the salmon to ascend to their spawning-grounds. In the absence of such regulations and requirements it will not be reasonable to expect that the results of fish-cultural work will be permanent or compensating, however extensive such work may be.
>
> A fish-cultural station planned to meet all the requirements must be very extensive and complete in all its appointments. * * * The hatchery must be commodious, providing * * * for the incubation of 1,000,000 salmon ova. It must also provide trough accommodations for holding 1,000,000 salmon fry for some weeks after they begin feeding. * * * An extensive system of ponds for rearing the salmon must be constructed, for none would be released in open waters until they were of sufficient size to have comparative immunity from capture by other fish. * * * The station should be * * * placed * * * convenient to transportation routes, and should control a gravity water supply which should be without stint or measure.

THE LAKE TROUT OR SALMON TROUT.

Next to the whitefish, the lake trout (*Salvelinus namaycush*) is probably the most highly esteemed species occurring in Lake Ontario, a popularity arising from its commercial importance, food value, game qualities, size, and beauty. Regarding the size of the Lake Ontario trout, it may be said that examples weighing 24 pounds are sometimes taken, but the average weight is much less than that. The fish caught in seines, on lines, etc., do not average more than 2 pounds, but in the large-meshed gill nets, set especially for trout, the average is probably 8 pounds.

Trout are now very scarce on the American shores of Lake Ontario, and the decrease in the catch since 1880 has been one of the most remarkable changes in the fisheries of that body of water. In 1880 over half a million pounds were taken; in 1890, although the yield was double that in 1885, only one-fourteenth of the catch in 1880 was obtained. The figures for the three years mentioned are as follows:

	Pounds.
1880	569,700
1885	20,510
1890	41,010

In many localities on the American shore, near which the lake trout were formerly very abundant and were taken in large numbers, they are now rarely seen. Off Oswego, for instance, the catch is now insignificant, but at one time thousands of trout were caught in summer in about 300 feet of water on set lines baited with ciscoes. There is an authentic record of two fishermen in one boat, operating about 800 hooks, taking 2,300 pounds of trout in one night. Now only a few fish visit the shores to spawn; this is usually in October.

Although differing widely from each other in habits, the trout and whitefish of Lake Ontario seem to be somewhat related in abundance and movements. The principal spawning-ground for the whitefish is also the locality most frequented by trout, and the largest quantities of each are taken in the same localities and at the same season. The trout, however, have decreased proportionally somewhat more than whitefish, the percentages being 93 and 86, respectively. As was shown in the consideration of the imports of fish from Canada, the provincial fishermen of Lake Ontario are now annually shipping into the United States larger quantities of lake trout than are caught by our fishermen.

Concerning the cause of the decreased abundance of trout in Lake Ontario, nothing definite can be asserted. The most plausible explanation seems to be that the largest quantities of fish are caught during or before the spawning season and on spawning-grounds, and that no adequate steps have been taken to replenish this unfortunate destruction of eggs and breeding fish. The U. S. Fish Commission has deposited no trout fry in Lake Ontario; and of the 35,444,800 young trout hatched by the New York fish commission between 1882 and 1891 not one has been planted in this lake, as I am informed by Mr. Edward P. Doyle, secretary of the New York fish commission.

The trout is a carnivorous and piscivorous fish, and in considering the question of increasing its abundance by resort to artificial means the food supply for young and adults becomes important. Fortunately it is thought that the alewives which now inhabit the lake in such countless myriads are admirably suited for trout food, a view which is sanctioned by the known habits of the trout and the opinion and experience of fishermen. The effect of the abundance of suitable food has been observed in the increased fatness of the fish caught. A dealer who handles large quantities of fish writes that he has noticed for several years that the trout caught in Lake Ontario are much fatter than those taken on the upper lakes, and it is now almost impossible to find a Lake Ontario trout that has not rolls of fat on its sides.

In regard to the feasibility of increasing by artificial means the abundance of lake trout, Mr. Ingersoll writes:

> I think the conditions are now very favorable for restocking this lake with salmon trout. The alewives are food for the young fry on the shores and shoals, and as soon as they get large enough to enter the deep water in the warm weather there are thousands of long-jaws for them to feed on.

THE COMMON WHITEFISH.

The present scarcity of the highly esteemed whitefish (*Coregonus clupeiformis*) in the American waters of Lake Ontario is one of the most noteworthy features of the fish life of the lake. The yield of this species is now only one-tenth what it was ten years ago, and in many localities in which the fish was formerly caught in considerable numbers it is now rarely, if ever, taken. The full extent of the decrease will be seen when it is stated that 1,064,000 pounds were obtained in 1880, while in 1890 the total yield was only 148,771 pounds.

The localities now chiefly resorted to by the whitefish are Charity Shoal, the Bay of Quinte, and around the Duck Islands; these are all in the eastern end of the lake. Charity Shoal has been for many years a famous breeding-ground for both whitefish and trout. The Bay of Quinte and the Duck Islands are in Canada, and are the centers of the most important whitefish fisheries now carried on in the lake. In the Bay of Quinte the fish run in very close to the shores, and the fishermen set their nets within a few rods of their dooryards.

The average weight of the whitefish now caught in Lake Ontario is about 2½ pounds. The maximum weight in recent years has been about 14 pounds. The largest specimen recently brought into Oswego from Canada weighed 12¼ pounds. At Sodus Point, where there was formerly a large run of whitefish, the gill-net fishermen now take only a few fish at a lift; these weigh from 5 to 14 pounds.

Observations on the spawning time of whitefish on the American shore go to show that this usually begins about November 10; it is, of course, subject to variation due to storms, temperature, etc.

The present scarcity of whitefish on the southern shores of the lake is not without precedent, although the length of the period of scarcity is probably greater than ever before known. There seems to have been a well-marked decennial diminution of whitefish on our shores through a long period of years, with a corresponding increase on the northern side of the lake. It is recorded,* for instance, that in 1870 whitefish were much more plentiful on the American shores; ten years before, the reverse was true; in 1880 the fish were less abundant on the southern side. In 1890, however, about which time, following the rule of the three previous decades, the whitefish should have reached the acme of their abundance on the shores of New York, they failed to appear; and, indeed, since 1880 the general tendency has been toward a decline on our shores, and the disparity between the two sides has been yearly more pronounced; while the experience of fishermen and personal observation indicate that the supply of whitefish in Canadian waters is annually increasing, and in 1891, in certain localities, was larger than for 20 years.

It is interesting to note that, in the experience of both anglers and fishermen, pike, bass, perch, pike perch, and similar predaceous species have increased on our shores in direct ratio with the decrease of the whitefish. Whether this is anything more than a coincidence is not known. The fish named, it may be observed, have had greater protection during the past decade than ever before. Fishing for them with nets has been practically stopped in waters adjacent to the shores. Incidentally whitefish and other species that do not readily take the hook have also had protection from

* The Fisheries and Fishery Industries of the United States, section I, p. 510.

man, but the question has arisen whether the unrestricted increase of piscivorous fishes has not influenced the abundance and movements of the weaker species. Thus, the protection of game fishes may be the cause of the present scarcity of whitefish on our shores. The writer does not advance this opinion as being entertained by him, but as the view of a certain class of people interested in the lake fisheries; the theory is to be accepted or discarded in the light of facts to be disclosed by additional inquiry.

By some fishermen it is claimed that the decrease in the whitefish is more apparent than real. They argue (1) that if the laws permitted greater freedom with nets fish would be found to occur on our shores in much larger quantities than is now supposed; and (2) that the serious decline in the catch of late years is due to the fact that fewer men are engaged and more restrictions are placed upon the capture of whitefish than formerly.

The extent to which the alewife is responsible for the general scarcity of the whitefish can only be surmised. It has been suggested that the great multiplication of the alewives has led to a partial exhaustion of the food supply of the various species of fish whose habits are non-predatory, chief among which is the whitefish. This question needs careful investigation before conclusions should be drawn, and can only be satisfactorily settled by an examination of the contents of full series of stomachs of whitefish and alewives. It may be stated that the available information bearing on this subject rather militates against the idea that the alewives consume the same kinds of food upon which the whitefish subsist, the former taking their food while freely swimming and the latter being essentially bottom-feeders.

Less attention has been given to the artificial culture of whitefish and fewer fry have been deposited in Lake Ontario than in any other of the Great Lakes. The reasons for this are (1) the New York fish commission has not had the facilities for doing this work on a sufficiently large scale, and the whitefish, being an essentially commercial species, has not profited by the otherwise liberal appropriations of the legislature which have been chiefly directed toward an increase of game fish; and (2) the Government hatcheries have been located at points too distant to warrant the introduction of large quantities of fry. It would seem that the time has arrived when the economic importance from a fishery standpoint of this magnificent body of water should be recognized, and steps taken to utilize the fine natural advantages which it offers for increasing the food supply of the region and adding to the wealth of the inhabitants.

The extent to which the fish commissions of the United States, Dominion of Canada, and State of New York have engaged in artificially stocking Lake Ontario with whitefish is shown in the following summary:

Whitefish fry planted in Lake Ontario.

Planted by—	No. of fry liberated.	Period.
United States	45,207,000	1882 to 1891
Dominion of Canada	34,350,000	1877 to 1890
State of New York	6,888,000	1877 to 1890
Total	86,445,000	

From the table it will be seen that for fifteen years the average number of young whitefish liberated annually in the waters of the lake has been 5,763,000, or about 890 fry to the square mile of lake surface. It must be apparent to fish-culturists and economists that if artificial stocking is to have any perceptible effect in increasing whitefish in Lake Ontario more generous plants will have to be made, and this can only come about by establishing hatching stations on or conveniently near the lake. The recent action of Congress in providing for the location of a hatchery in this region is a step of great importance to the fisheries of the lake, and similar legislation is looked for on the part of the State of New York, whose interests in this matter are very great. With the establishment of a station of design similar to the hatchery of the Michigan commission at Detroit or that of the Government at Put-in-Bay, Ohio, each of which has a capacity for hatching 150,000,000 to 200,000,000 whitefish eggs annually, it is thought that only a few years will have elapsed before the abundance of whitefish in Lake Ontario will be satisfactorily and materially increased.

THE LESSER WHITEFISHES.

Lake Ontario is included within the range of a number of other species of *Coregoni* which have been appropriately designated the "lesser whitefishes." It is probable that four of these occur in the lake. These are the lake herring or cisco (*C. artedi*); the moon-eye, or Hoy's whitefish (*C. hoyi*); the menominee or round whitefish (*C. quadrilateralis*), and the mongrel whitefish, or tullibee (*C. tullibee*). The cisco is such a common and well-known fish that no special study was necessary; two of the others were not observed, and, in the limited time available for the investigation, it was not possible satisfactorily to identify all the fish by the numerous names applied by the fishermen in the various parts of the lake.

The lake herring is usually known as the cisco throughout Lake Ontario. The name herring is also in use, and the designation "greenback" was heard in Wayne County, to which it appears to be restricted.

The cisco is a very abundant fish in the waters of Lake Ontario, where it ranks as one of the most important economic species, although it is less numerous than formerly. The principal fisheries at present are in Jefferson County, gill nets being the apparatus chiefly used. The fish come to the shores in the fall and winter to spawn, and it is at that time that the most fishing is done.

Since the bloater whitefish has assumed commercial importance the abundance of ciscoes appears to have been considerably reduced at many fishing centers on the American shore; and in some communities in which they formerly constituted the principal part of the catch they are now taken in only one-tenth the quantity that bloaters are. This, for example, is the case at Wilson, New York.

The average weight of the cisco of Lake Ontario is three-quarters of a pound. Examples weighing 3 to 3½ pounds are not rare. The largest individuals taken weigh about 4½ pounds, but fish of such size are only occasionally obtained.

The cisco belongs to that group of whitefishes chiefly characterized by a projecting lower jaw, a feature which produces a larger mouth, which in turn indicates a greater range of food than is possessed by the common whitefish. In addition, therefore, to feeding on minute organisms, such as form the pabulum of the whitefish, the cisco takes small fish. In the summer of 1891 an Oswego fisherman speared a 3-pound

cisco in whose mouth was a large alewife which had just been seized. The young alewives are said to have been repeatedly found in the stomachs of the lake herring.

Hoy's whitefish, or the lake moon-eye, is one of the smallest *Coregoni* occurring in the Great Lakes, and it is considered to be the handsomest member of the genus. According to Jordan, the average length is only 1 foot and the weight only half a pound, but specimens considerably larger occur in Lake Ontario, some of those seen being 18 inches long and weighing nearly 2 pounds. This species resembles the cisco (*C. artedi*) and differs from the regular whitefish in having the lower jaw projecting instead of included, and is further distinguished from the common whitefish by having less elevation of the back. The upper part of the body is of bluish color, and the sides and under parts have a very brilliant silvery reflection. The moon-eye is essentially a deep-water fish, and in Lake Ontario it is never observed in shallow water.

The menominee or round whitefish differs from the other species in having a remarkably small and narrow mouth, situated on the under side of the snout. Its back is not elevated as in the common whitefish. It frequents the deeper waters of the lake.

The mongrel whitefish or tullibee reaches a length of 18 inches, and is a stout and deep fish, with a projecting lower jaw. It is a species inhabiting deep water, and is very prolific.

In the absence of specimens, it would be futile to attempt to assign to the various less common species the names given by the fishermen. The most that can be done is to record the vernacular designations, together with such information as could be obtained regarding the fish represented, and to defer the settlement of the question until further data shall be secured. It is hoped that the presentation of the illustrations of the rarer whitefish may aid in bringing about a clearer and wider knowledge of the fish life of the lake.

Under the names "bloater" and "round whitefish" the fishermen of the eastern end of the lake recognize a species (probably *Coregonus hoyi*) which is smaller than the common whitefish, usually attaining a length of only 15 inches and weighing less than a pound. A few years ago the fish was almost unknown to the fishermen making their headquarters at Cape Vincent, the principal fishing center on the lake, but of late considerable quantities have been taken, and the fish appears to be increasing in numbers with great rapidity. It has soft, oily flesh, and during recent years has commanded only half the price of regular whitefish.

This may be the same fish which further west on the shores of the lake is known by various other names. At Oswego, for instance, the names heard were "bloater," "bloater whitefish," "silver whitefish," "Ontario whitefish," "siscowet" or "ciscoette," and "long jaws"; it seems very probable, however, that more species than one are included in this list. In 1885* it was remarked of the fish called "siscowet" or "silver whitefish" at Oswego, that it was quite plentiful, weighed from 1½ to 2 pounds, and sold almost as readily as the common whitefish. This fish in 1890 and 1891 was said to be less abundant than formerly in the vicinity of Oswego. The fish is found in much deeper water than the common species, being taken in gill nets at a depth of 600 feet. It is said to be very prolific.

To what extent the decrease in the regular whitefish may be influenced by the abundance of these fish in different parts of the lake is yet to be determined.

* Review of the Fisheries of the Great Lakes, p. 316.

THE PIKE PERCHES.

The decrease in the abundance of whitefish and trout during recent years has brought the pike perches into greater commercial prominence than they ever before attained. This is particularly true of the wall-eyed or yellow pike (*Stizostedion vitreum*), which is taken in much greater numbers than the other species. In many localities, more especially in the eastern end of the lake where the most important fisheries are prosecuted, the wall-eyed pike (also called pickerel) has become the most highly-prized fish taken, and yields the fishermen from 2 to 5 cents per pound more than whitefish and trout. The average price at Cape Vincent during the past two years has been 8 or 10 cents per pound, although at times in 1890 the price advanced to 14 cents. Many fishermen who formerly caught whitefish and trout now almost confine their operations to the taking of "pickerel," which in the important trap fisheries in Jefferson County constitutes about one-third of the total quantity of fish taken and yields three-fifths of the total income of the trap-net fishermen. From the foregoing facts it will be seen that the fishermen and fish-dealers have reason to desire that the supply of wall-eyed pike shall be maintained and increased, and they are almost unanimous in looking to artificial propagation as the means to accomplish this end. It is expected that when the United States hatching station is established on Lake Ontario, wall-eyed pike will be one of the chief species propagated.

At Oswego, where the species is called the yellow pike, and at other places along the western shore of the lake, this fish is now scarce and has been so for some years, and will always yield the fishermen 10 or more cents a pound.

It has been observed that in spring the wall-eyed pike is found close to shore; by summer it has left the shore and frequents the shoals in the lake; in fall it seeks the deeper water and remains there throughout the winter. In 1890 the fish was tardy in retiring from the shoals and was taken in considerable numbers on Charity Shoal as late as October 20. Soon after coming from the deep water the fish spawns, frequenting for this purpose the shores and the mouths of rivers and creeks. The spawning season usually occupies the month of April, and, fortunately, the reproductive process is about completed by the time the fishing season opens.

In 1880 it was recorded that since the introduction of the alewife the wall-eyed pike had apparently increased in size. Observations in the summer of 1891 showed that the alewife constituted the chief food of the fish and was no doubt the cause of its great fatness. The average weight of fish now taken is 4 pounds and the maximum is 14 pounds.

The variety of wall-eyed pike known as the blue pike (*S. vitreum*, var. *salmoneum*) is not abundant in Lake Ontario, and in most localities is rare. In 1891, in the vicinity of Oswego, there was a most remarkable run during the summer months, which contrasted strongly with the previous scarcity of the species. For about six weeks from July 1, the Oswego River and the adjacent lake waters were frequented by enormous quantities of blue pike which attracted large parties of sportsmen and others; at times more than 500 people were fishing from boats, wharves, and piers. It is estimated that not less than 150,000 fish were taken during this time. The fish were mostly of small size, weighing from 2 ounces to 2 pounds, although many individuals weighing 4 pounds were secured; the average weight was probably less than half a pound.

The sauger (*S. canadense*) has always been more or less uncommon in Lake Ontario, and now appears to be less numerous than ever before. The few specimens taken of late have been mostly from Chaumont Bay. The sauger occurring in the lake and the St. Lawrence River differs considerably from the fish found in the other lakes, and is regarded as a distinct variety, chiefly characterized by a rougher head more extensively and closely covered with scales, and an increased number of spines on the opercles. At Oswego the name "mad pike" was heard applied to the sauger.

THE STRAWBERRY BASS OR CALICO BASS.

From the various standpoints of angler, commercial fisherman, and fish-culturist, the strawberry bass (*Pomoxis sparoides*) is one of the most valuable and least appreciated fishes of Lake Ontario. In Lake Erie, under the name grass bass, the fish is an important food species, but in Lake Ontario it is not of economic value at the present time. It occurs chiefly in the bays, ponds, and bayous with grassy shores connected with or adjacent to the lake, and seems to be especially abundant in Irondequoit Bay, Monroe County. As long ago as 1874, the late Prof. Kirtland accorded high praise to the strawberry bass, and his testimony, being in great measure applicable to the present time, deserves careful consideration. He says:

> The grass bass has not hitherto been deemed worthy of consideration by fish-culturists; yet, from a long and intimate acquaintance with its merits, I hesitate not to pronounce it the fish for the million. It is a native of our western rivers and lakes, where it usually resorts to deep and sluggish waters; yet in several instances, where it has found its way into cold and rapid streams and even small-sized brooks, by means of the constructing of canals or by the hand of man, it has adapted itself to the change, and in two or three years stocked to overflowing these new locations. As a pan fish, for the table, it is surpassed by few other fresh-water species. For endurance and rapidity of increase it is unequaled. The grass bass is perfectly adapted to stocking ponds. It will thrive without care in very small ponds of sufficient depth. It will in no wise interfere with the cultivation of any number of species, large or small, in the same waters. It will live harmoniously with all others, and while its structure and disposition restrain it from attacking any other but very small fry, its formidable armature of spinous rays in the dorsal and abdominal fins will guard it against attacks of even the voracious pike. (American Sportsman, February 28, 1874.)

The strawberry bass of Lake Ontario is a fine fish, weighing from a half pound to 2 pounds. As a fish for anglers, it has few superiors in the lake region, being a vigorous and prompt biter and a scarcely inferior substitute for the black bass. In 1890 two anglers in Irondequoit Bay took 120 of these fish during part of one day, a circumstance which illustrates the abundance of the species and the readiness with which it takes the hook. Without any apparent encouragement the fish has greatly increased in several localities of late years, and the facility with which it can be propagated and acclimated in ponds and bays along the shores of Lake Ontario strongly recommends it for additional attention by fish-culturists.

BAIT FISHES.

With a view to protect the game fish, laws have been enacted in New York restricting the means of capture to hook and line in the St. Lawrence River and within a certain distance of the shore in Lake Ontario. The use of small-meshed seines to supply bait minnows for angling is permitted, and enormous quantities of minnows are thus annually consumed. In the river and at the numerous fishing resorts on the lake more than 100 men and boys give more or less exclusive attention to seining minnows during the angling season, and generally secure handsome returns, the ruling prices for minnows being from ½ cent to 2 cents each.

The yearly drain on the minnows is not without its results, especially in the St. Lawrence River, where the supply is said to have been much diminished in 1891, and minnow fishermen in the vicinity of Alexandria Bay were often obliged to go in their boats a distance of 20 miles to Lake Ontario to find sufficient quantities of small fish, although at one time all the bait consumed in the river was caught locally.

Careful estimates, based on information furnished by bait-dealers and others, show the number of minnows caught for bait in 1891 in Lake Ontario and its tributaries and in the St. Lawrence River to have been not less than 9,000,000, including those which died before being used and were thus sacrificed. The mortality is very large.

Besides the minnows, so called, used for bait, considerable destruction of immature fish occurs. Young fish of almost every species are naturally taken in the seines, and are classed as "minnows" or "bait" by the dealers. Unfortunately, small whitefish are not exempt, and in the vicinity of Fox Island, where whitefish formerly spawned in great numbers and where the young now appear to congregate at times, considerable quantities are sometimes taken for bait; these are from 1½ to 3 inches long. Small trout, bass, pike, and herring are also used whenever they happen to be taken.

This matter is not without its practical bearing on the question of food and food supply of the piscivorous fishes and the following list of bait minnows is offered as a fragmentary contribution to the subject. The species mentioned were obtained from bait fishermen in various localities on the southern shore of Lake Ontario. The list could of course be greatly extended by a special investigation; as it stands, it simply represents the personal observations incidentally made by the writer. The local names applied to the fish, so far as heard, are given in quotation marks.

1. **Catostomus teres** (Mitchill). *Common sucker; "Mullet."*

This is a well-known fish in Lake Ontario, and is often used for food. It attains a length of 18 inches. When of small size it is frequently employed as a bait. Six specimens, about 1¾ inches in length, were obtained from minnow fishermen.

2. **Campostoma anomalum** (Rafinesque). *Stone-roller; Stone-lugger.*

Four specimens of this interesting species were preserved, the largest of which was 2⅜ inches, the smallest 1¾ inches. These differ much in color from more mature examples. The upper parts are of a dark-brownish color, with faint mottlings; the under parts are white. A blackish lateral band about width of eye extends the entire length of body and appears as a bar on the snout; above the dark band is a narrower light one.

3. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow; "Sucker."*

One of the most important and abundant baits. It is easily distinguished by its sucker-like head and the black spot at the base of tail. Frequently seen around wharves feeding on decayed fish. Takes the hook readily; at Cape Vincent dozens were caught on a pinhook baited with a piece of angleworm. The six specimens preserved were about 3 inches long.

4. **Notropis hudsonius** (De Witt Clinton). *Spawn-eater; "Chub."*

Reaches a length of 10 inches, and is abundant in Lake Ontario. It is a common bait for bass and pike. Three specimens were preserved, the largest 3¼ inches long.

5. **Notropis whipplei** (Girard). *Silver-fin; "Shiner."*

The name "shiner" was heard applied to this minnow by fishermen. It is less common than the preceding species. A single specimen was preserved. This was a male, 3¼ inches long, with the head, nape, and back anterior to dorsal fin thickly beset with short, broad-based spines.

6. **Notropis megalops** (Rafinesque). *Common shiner; Red-fin; Dace.*

The most abundant member of the genus *Notropis* and one of the minnows most commonly used for bait. Eighteen specimens were collected, the largest of which was 4½ inches long. The species attains a length of about 8 inches. A number of the examples obtained were affected with the larvæ of a parasitic worm (Trematod), manifested in the form of small round black spots thickly scattered over the body and fins. These parasites were found also on *Catostomus teres* and *Semotilus atromaculatus*. In Irondequoit Bay minnows kept in captivity were very frequently attacked in this way.

7. **Notropis heterodon** (Cope).

A single specimen, 2½ inches long, has been identified by Dr. Charles H. Gilbert as belonging to this species.

8. **Hybopsis kentuckiensis** (Rafinesque). *Silver-fin; Horny-head; "Chub."*

A very common and important bait minnow for bass and pike. It reaches a length of 10 inches, but none of the seven specimens preserved was over 3½ inches long.

9. **Semotilus atromaculatus** (Mitchill). *Horned dace.*

A common bait fish, usually found in the clear streams entering the lake. The five specimens obtained were only about 2 inches long, although the fish attains a length of 10 or 12 inches. The fall fish or roach (*Semotilus bullaris*) was not seen, but it is an abundant inhabitant of the lake region, where it reaches a much larger size than the preceding.

10. **Clupea pseudoharengus** (Wilson). *Alewife; "Shad."*

This brilliant silvery fish is often used for bait when immature. One example, 2¼ inches long, was received from a bait fisherman at Grenadier Island August 12, 1891.

11. **Umbra pygmæa** (Dekay). *Mud minnow; "Dogfish."*

Occurs in shallow places with weedy and muddy bottom. One specimen, 3½ inches long, was obtained from a bait fisherman in Irondequoit Bay.

12. **Etheostoma nigrum** (Rafinesque.) *Johnny darter.*

Not uncommon in small brooks debouching into Lake Ontario, and often taken in minnow seines. One specimen preserved.

HOW THE FISHERIES OF LAKE ONTARIO MAY BE IMPROVED.

The State of New York at the present time is expending considerable money in carrying out the provisions of restrictive fishery laws applicable to Lake Ontario. The State has valuable interests dependent on the preservation of its fishes, more especially the game species; and it is chiefly with a view to protect these interests that a fishery code has been enacted particularly favorable to angling and inimical to commercial fishing. As a result, there is much discontent among those citizens who live chiefly by fishing, and a more liberal policy is much desired by them. The scarcity of fish, however, seems to the legislature a sufficient cause for restrictive laws, and under the present conditions it is not probable that material changes will be made in the statutes. This being the case, it seems that the only hope which may be entertained by the professional fisherman for obtaining greater freedom in his pursuit depends on an increase, either naturally or artificially secured, in the abundance of fish in the lake.

The entire history of the fisheries of Lake Ontario tends to prove that even under the radically restrictive laws which have been in force for a sufficient length of time to test their effects, some of the most valuable fishes have not been competent to replenish the lake to such an extent as to warrant the abrogation of a legal check on their capture, and the intervention of man seems to be urgently demanded. The agitation by the fishermen of this phase of the subject seems more rational and more likely to accomplish the desired results than direct efforts to obtain a less rigorous fishery code. It has always been the policy of the U. S. Fish Commission, whenever the occasion arose, to advocate the maximum expense for and attention to the increase of fish by recourse to positive methods, in order that there may be necessity for resort to the minimum amount of prohibitive legislation.

A study of fish-culture, as practiced in the waters of Lake Ontario, leads to the conclusion that none of the Great Lakes has received less attention. While in other lakes the natural decline in the abundance of food-fishes incident to the prosecution of important commercial fisheries has been mitigated and in many instances completely reversed by the rational resort to artificial propagation, in Lake Ontario fish-culture has been a secondary consideration in the attempts to increase the supply of fish, and restrictive and prohibitory measures have been the remedies most persistently advocated and resorted to. This policy has not led to any increase in the fishes sought to be protected, but, on the contrary, has, in the case of the two most important species, resulted in the most alarming and phenomenal decrease which has probably ever occurred in a body of water of similar size and with like natural advantages. The decrease of 915,229 pounds in the catch of whitefish in the waters of Lake Ontario tributary to New York, between 1880 and 1890, was met by the planting by the State of New York of 6,888,000 whitefish fry in the same lake during the same period. Since 1880 the quantity of lake trout taken in the lake by citizens of New York has been reduced 528,690 pounds, during which time the State has not deposited a single young trout in the waters of the lake, but has planted 35,444,800 fry in inland waters having no commercial fisheries. These subjects are referred to at greater length in the special chapters relating to the individual species, and need be only incidentally mentioned in this place.

There can be no doubt whatever that the waters of Lake Ontario are capable of sustaining fisheries of as great relative magnitude as those of any other of the Great Lakes. It is equally true that the creation of an abundance of fish necessary to maintain these fisheries is entirely within the province of fish-cultural work. In the words of U. S. Fish Commissioner McDonald, "it is not only possible, it is entirely practicable, to restore and maintain these fisheries by adequate resort to means and agencies entirely within our control." The "means and agencies "consist of well-known and approved fish-cultural methods which, in other lakes and waters under similar conditions, have been successful.

At comparatively small expense, one or more hatching stations could be established on the shores of Lake Ontario, the results of whose operations after a few years would be an increased supply of food-fish whose value to the State would be a profitable and perpetual return for the original outlay. At such hatcheries whitefish, lake trout, pike perch, salmon, and sturgeon should be artificially propagated.

In connection with the fish-cultural work the question of temporarily prohibiting fishing for whitefish and trout during the spawning period, and of limiting the size of these and other species marketed, would come up for consideration; but sufficiently large plants of fry would probably, after a short time, obviate the necessity for any restrictive fishery measures.

NOTES ON THE ACCOMPANYING PLATES.

Illustrations of all of the principal economic and game fishes occurring in Lake Ontario are presented with this report. It is thought that this feature of the article will contribute to a clearer knowledge of the lake fishes on the part of fishermen and others. The species figured are as follows:

Plate XXI. *Acipenser rubicundus* Le Sueur. Lake sturgeon.

Plate XXII. *Amia calva* Linnæus. Dogfish; Mudfish.

This fish has no commercial value, and is only interesting because of its anatomical relations, its destruction of other fish, and its extremely tenacious hold on life. It reaches a length of 2½ feet and a weight of 15 pounds. It may be taken with a hook or trolling spoon. The young are considered excellent bait for pike.

Plate XXIII. *Ameiurus vulgaris* (Thompson). Bullhead.

This is one of the common catfishes of Lake Ontario, where it reaches a length of 18 inches. Although called bullhead, it is to be distinguished from the more abundant bullhead or horned pout (*A. nebulosus*), which has the upper jaw longer than the lower, while in the species figured the upper jaw is usually shorter than the lower.

Plate XXIV. *Catostomus teres* (Mitchill). Common sucker; Brook sucker; Mullet.

In the statistical tables the fish enumerated as suckers consist chiefly of this species. It attains a length of 2 feet and has considerable commercial value in some places, but its edible qualities are inferior. The fish ascends streams in the breeding season and is there taken in seines and with spears.

Plate XXV. *Moxostoma anisurum* (Rafinesque). Carp mullet.

Distinguished from the redhorse, which also occurs in the lake, by the much larger fins and by the coloration of the lower fins. In the redhorse they are red or orange; in this species, white.

Plate XXVI. *Cyprinus carpio* Linnæus. Leather carp.

This fish has been introduced into Lake Ontario and has also accidentally found its way there by the breaking of dams. It appears to thrive well in the cold, clear waters of the lake, and some fine examples have been caught in recent years by net fishermen.

Plate XXVII. *Semotilus atromaculatus* (Mitchill). Horned dace; Chub.

The horned dace is found mostly in the smaller streams and bays tributary to the lake, where it reaches the length of a foot. It is often caught by the boys on hooks baited with angle-worms. The species is distinguished by a large, black spot on the anterior part of the dorsal fin. The male fish, in the breeding season, develops peculiar dermal protuberances on the head, whence the name "horned dace."

Plate XXVIII. *Hiodon tergisus* Le Sueur. Moon-eye.

This is a handsome fish, with a brilliant silvery color on the sides and green above. It has recognized game qualities, and takes the fly or baited hook with avidity. Feeds on minnows, insects, and crustaceans. It weighs 1 or 2 pounds, but is not generally esteemed as a food-fish.

Plate XXIX. *Clupea pseudoharengus* Wilson. Alewife; Branch herring.

Plate XXX. *Clupea sapidissima* Wilson. Shad.

Plate XXXI. *Clupea chrysochloris* (Rafinesque). Skipjack.

Although not observed by the writer in Lake Ontario, its occurrence there can hardly be doubted. The fish is abundant in Lake Erie, to which it gained access by means of canals communicating with streams of the Mississippi Valley. The fish reaches the length of a foot or more. It is of little value as food.

Plate XXXII. *Dorosoma cepedianum* (Le Sueur). Mud shad; Gizzard shad.

Like the skipjack, this fish has entered the Great Lakes through canals, and has become very abundant in lakes Michigan and Erie. Its flesh is coarse and not of a delicate flavor. The fish is about a foot in length and is readily distinguished by the elongated ray in the dorsal fin.

Plate XXXIII. *Coregonus clupeiformis* (Mitchill). Common whitefish.

Plate XXXIV. *Coregonus artedi* Le Sueur. Cisco; Lake herring.

Plate XXXV. *Coregonus hoyi* (Gill). Hoy's whitefish; Lake Moon-eye; Long-jaw.

The specimen figured was from Seneca Lake, New York, and represents a much more slender race than is found in Lake Ontario. The resemblance between this species and the cisco is great. In a special paper on this fish, now in course of preparation, its relations, habits, commercial importance, etc., will be considered.

Plate XXXVI. *Coregonus quadrilateralis* Richardson. Round whitefish; Menominee whitefish.

Plate XXXVII. *Coregonus tullibee* Richardson. Tullibee; Mongrel whitefish.

Plate XXXVIII. *Salmo salar* Linnæus. Atlantic salmon.

Plate XXXIX. *Salvelinus namaycush* (Walbaum). Lake trout; Salmon trout.

Plate XL. *Esox lucius* Linnæus. Pike; Pickerel.

Plate XLI. *Esox nobilior* Thompson. Muskellunge.

This magnificent fish is comparatively rare in Lake Ontario, but is more or less abundant in the St. Lawrence River. Examples weighing 65 pounds have been taken in the lake, but the maximum in recent years has been much less. This fish may always be distinguished from the pike (*E. lucius*) by having the lower part of the cheek destitute of scales.

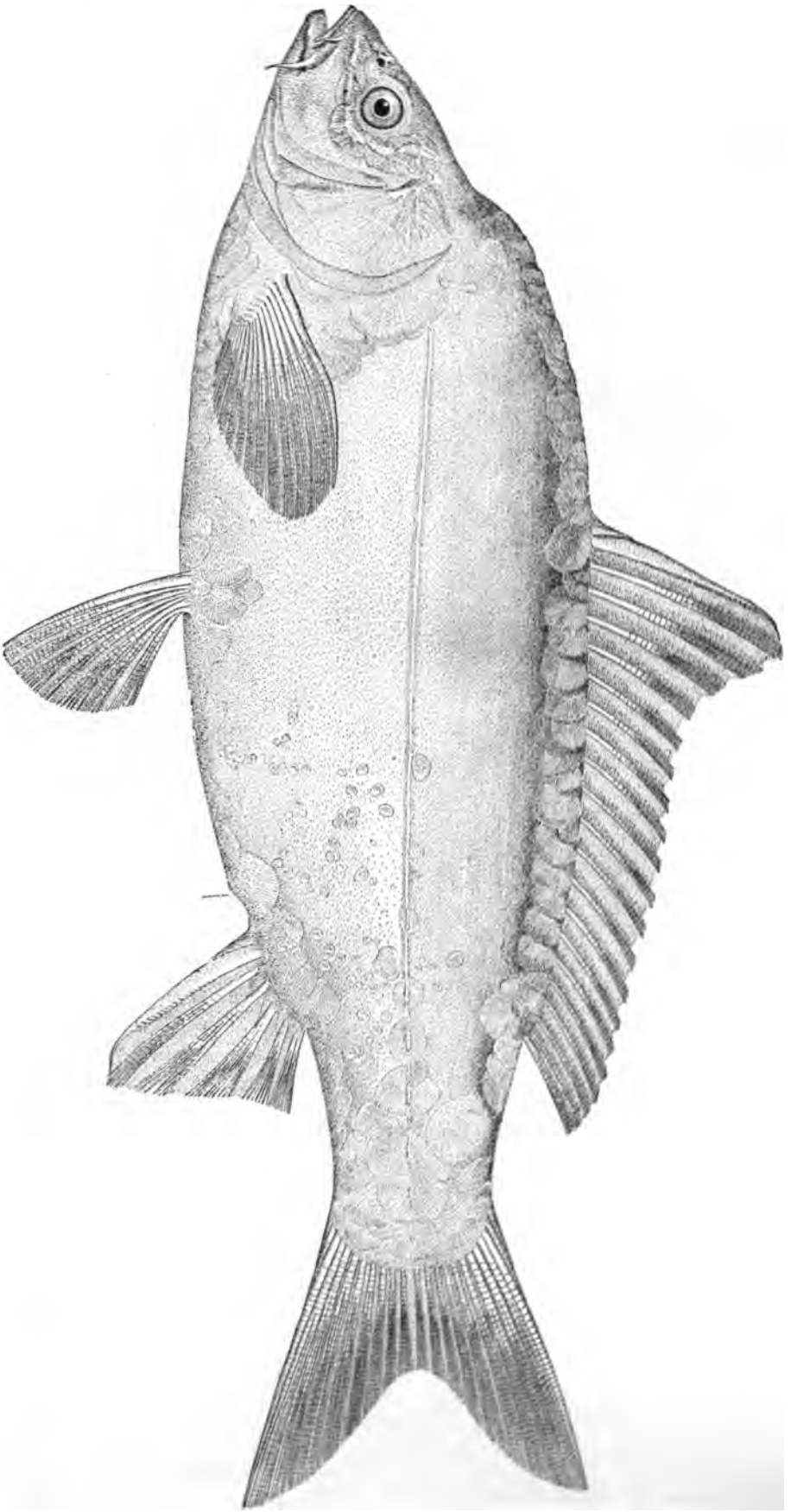
Plate XLII. *Pomoxis sparoides* (Lacépède). Strawberry bass; Calico bass.

Plate XLIII. *Ambloplites rupestris* (Rafinesque). Rock bass.

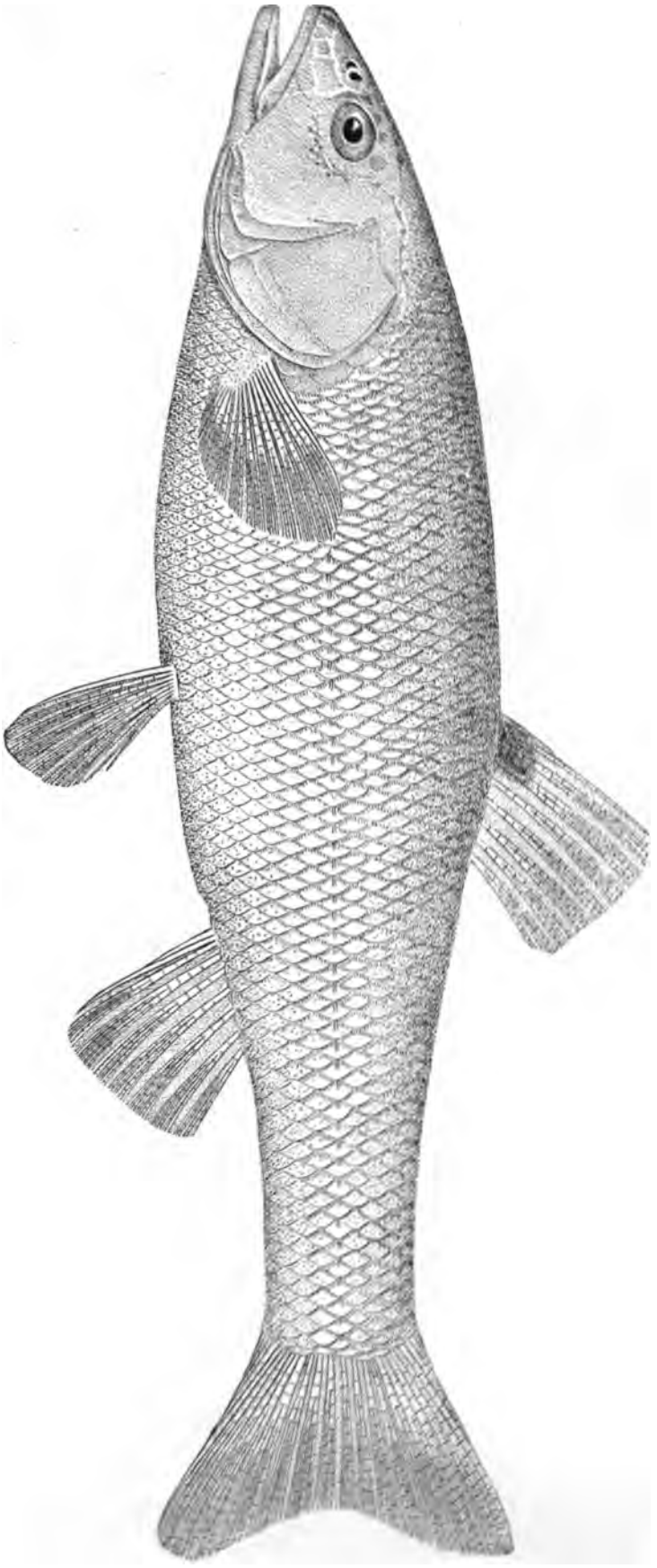
Abundant in Lake Ontario in suitable situations, and is taken for market in seines, hoop nets, etc. It has pronounced game qualities, and readily takes a hook baited with live minnow. The weight attained is 1½ pounds. Spawns in summer like the black bass.

Plate XLIV. *Micropterus salmoides* (Lacépède). Large-mouthed black bass; Oswego bass.

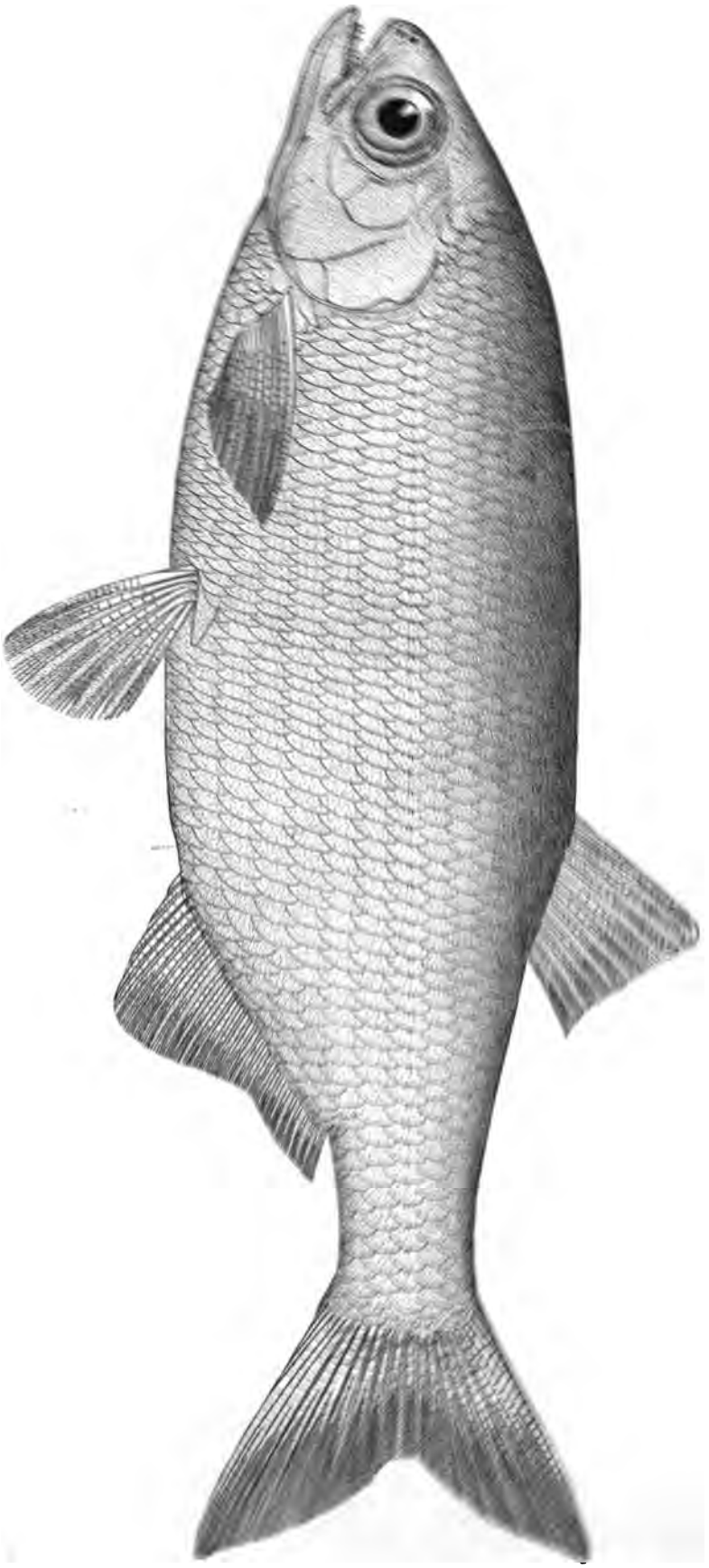
This popular species is very abundant in Lake Ontario and its tributaries. While found in the clear, rapid water of the St. Lawrence River and other similar streams, it appears to be most at home in quiet or sluggish waters overgrown with rushes and other aquatic plants. The large-mouthed black bass may be distinguished from the other species with which it is generally associated by its larger mouth, the extension of the maxillary bone beyond the orbit, the less numerous and larger scales on the cheeks, the fewer soft rays in the dorsal fin (12 instead of 13), and many other characters.



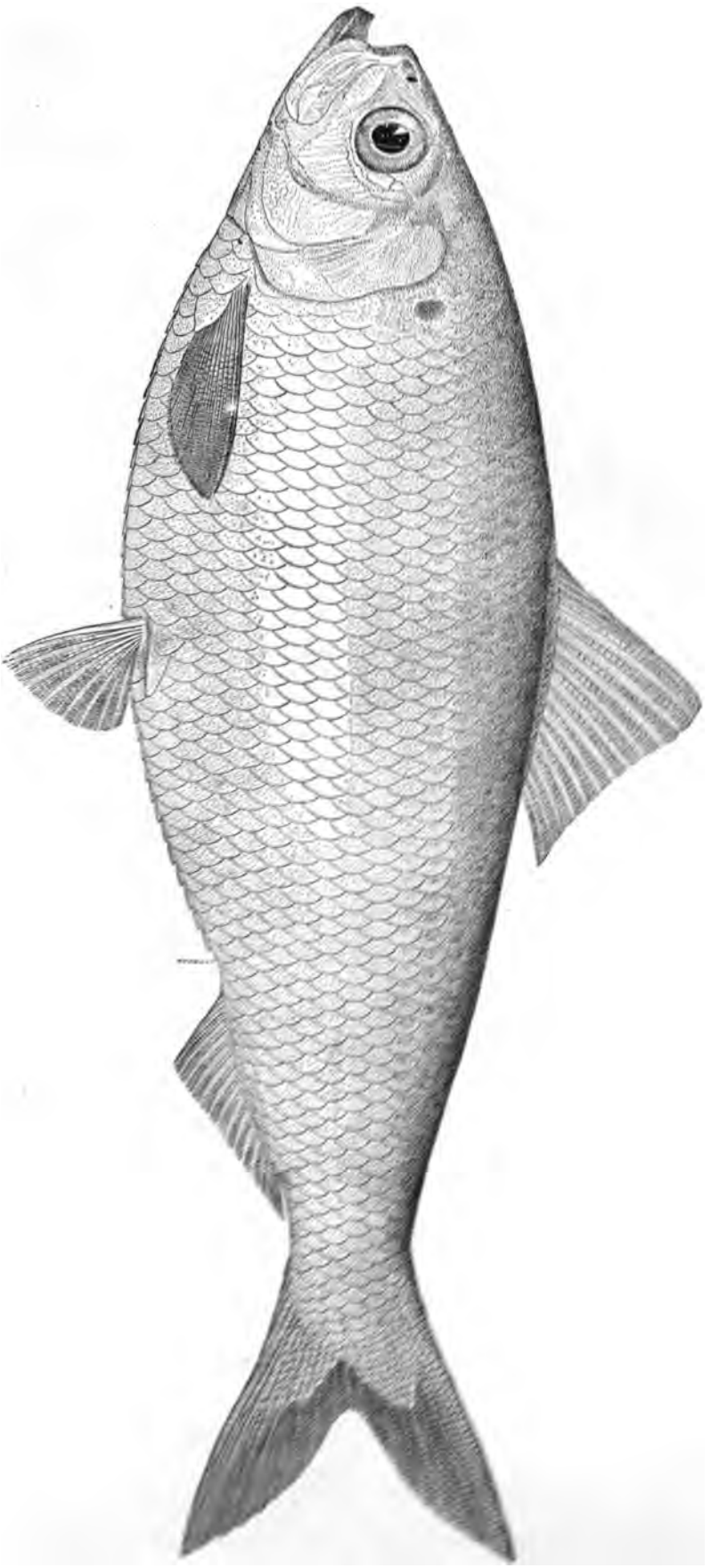
CYPRINUS CARPIO Linnæus. *Leather Carp.*



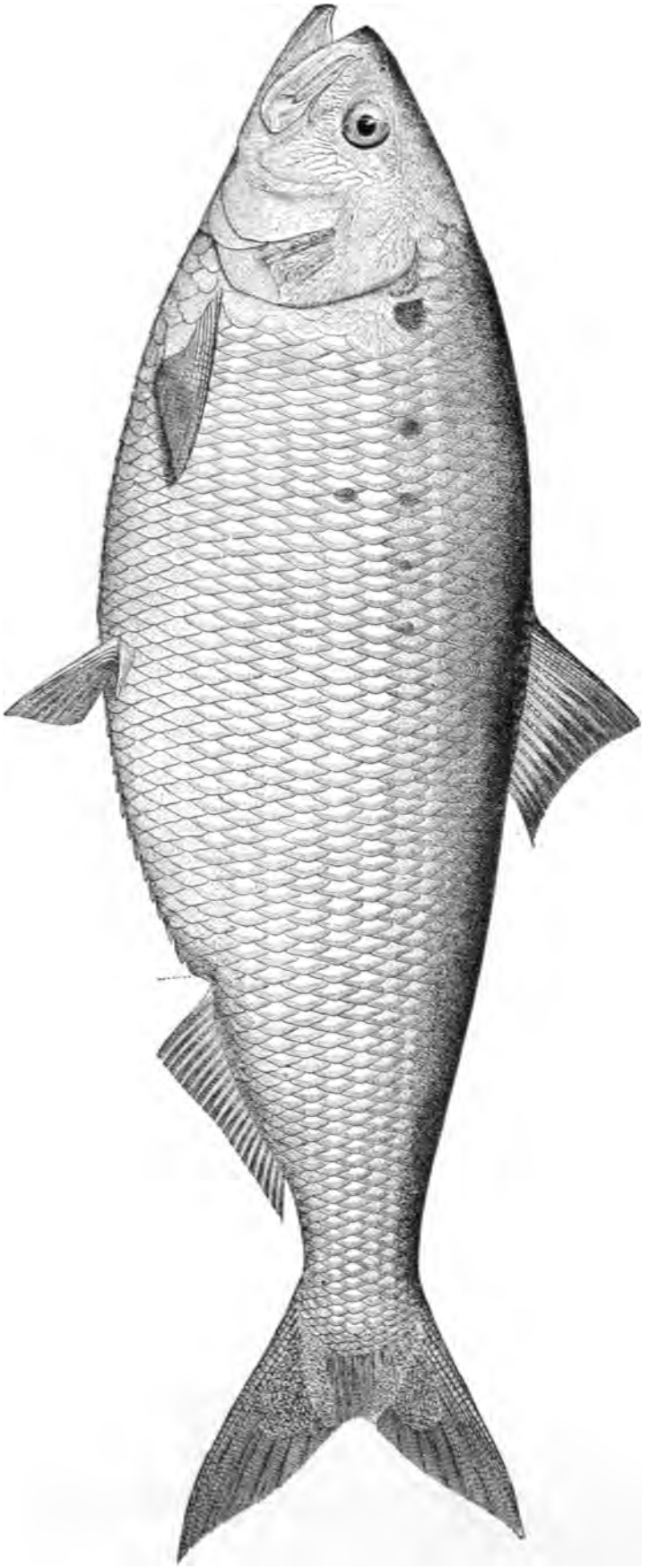
SEMOTILUS ATROMACULATUS (Mitchill). *Horned Dace; Chub.*



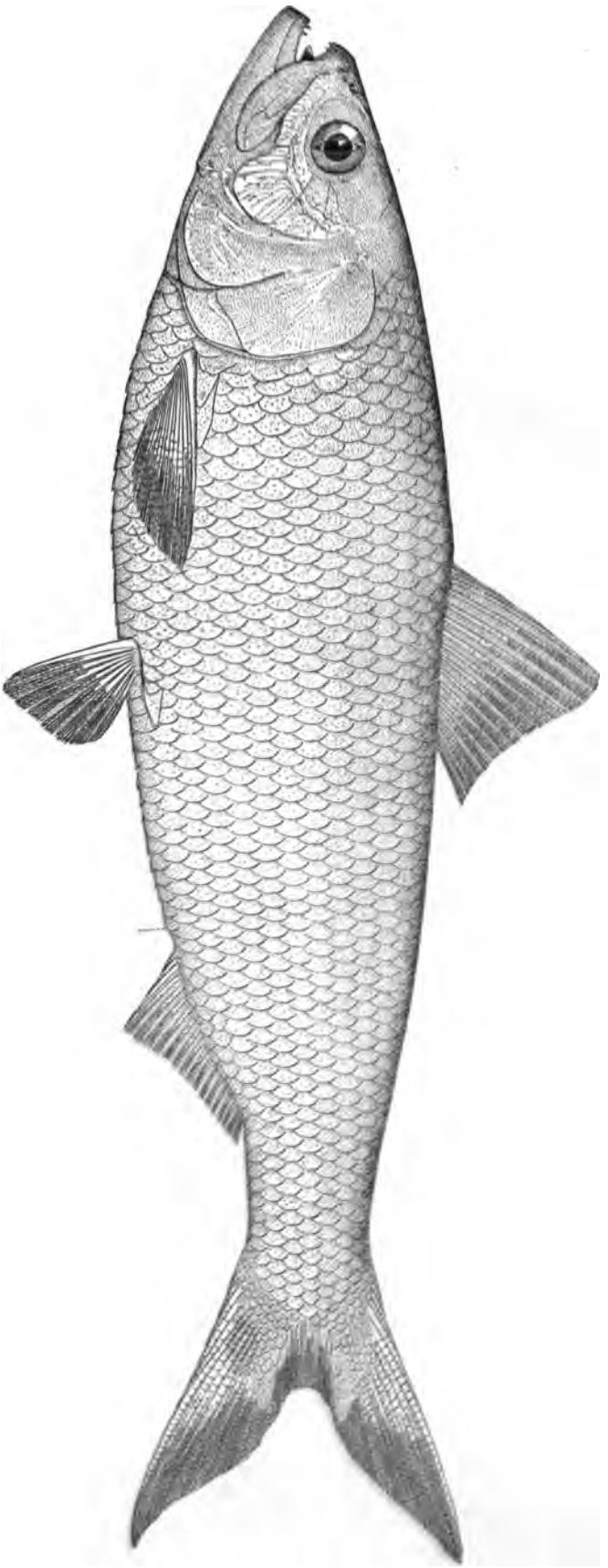
HIODON TERGISUS *Le Sueur.* ***Moon-eye.***



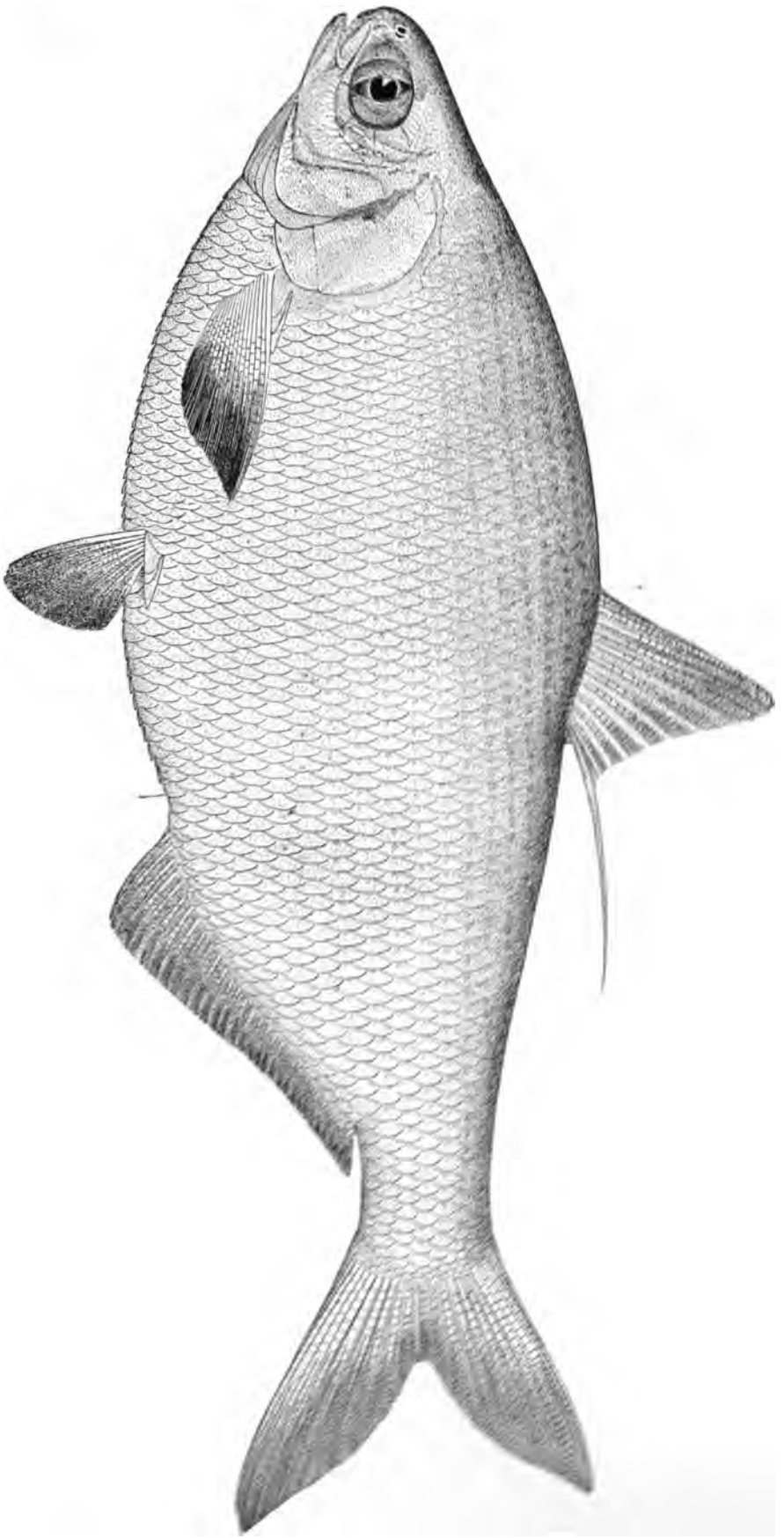
CLUPEA PSEUDOHARENGUS Wilson. *Alewife; Branch Herring.*



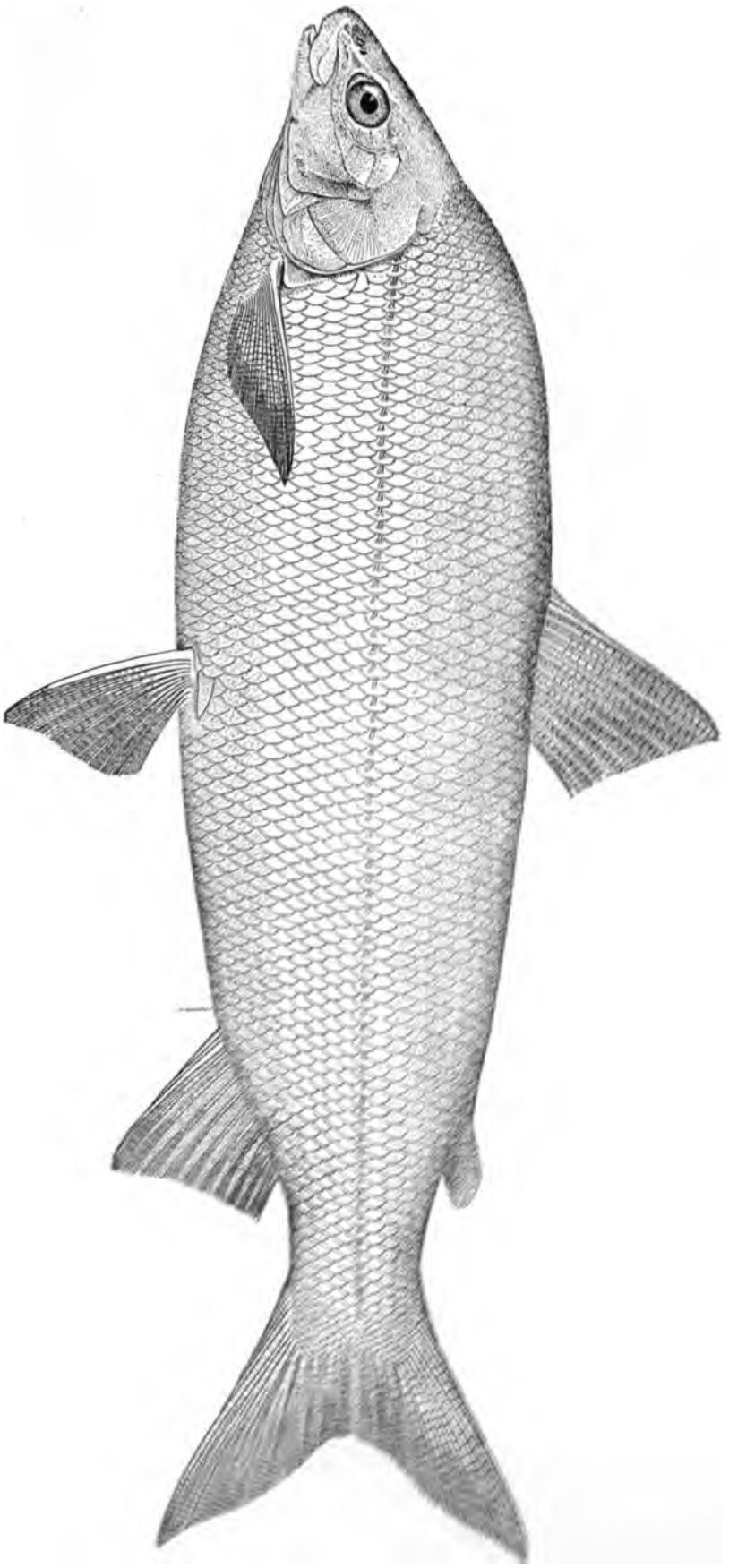
CLUPEA SAPIDISSIMA Wilson. *Shad.*



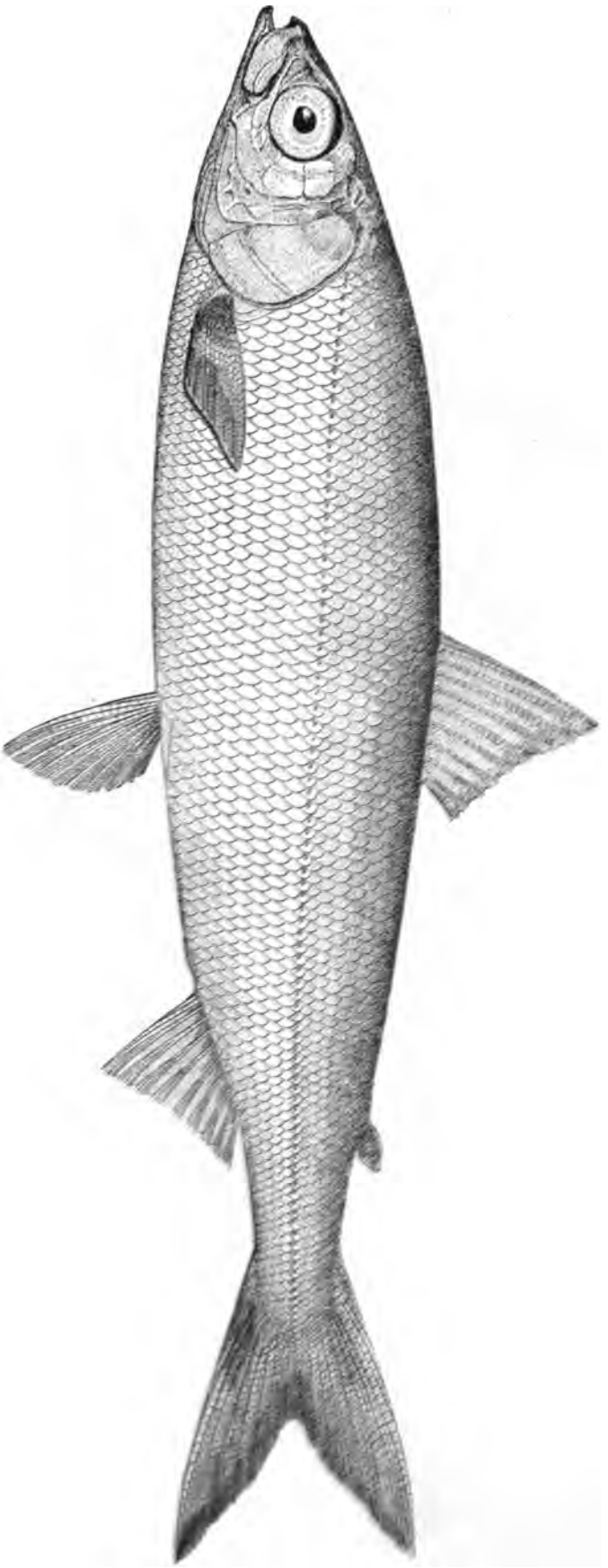
CLUPEA CHRYSOCHLORIS (Rafinesque). *Skipjack.*



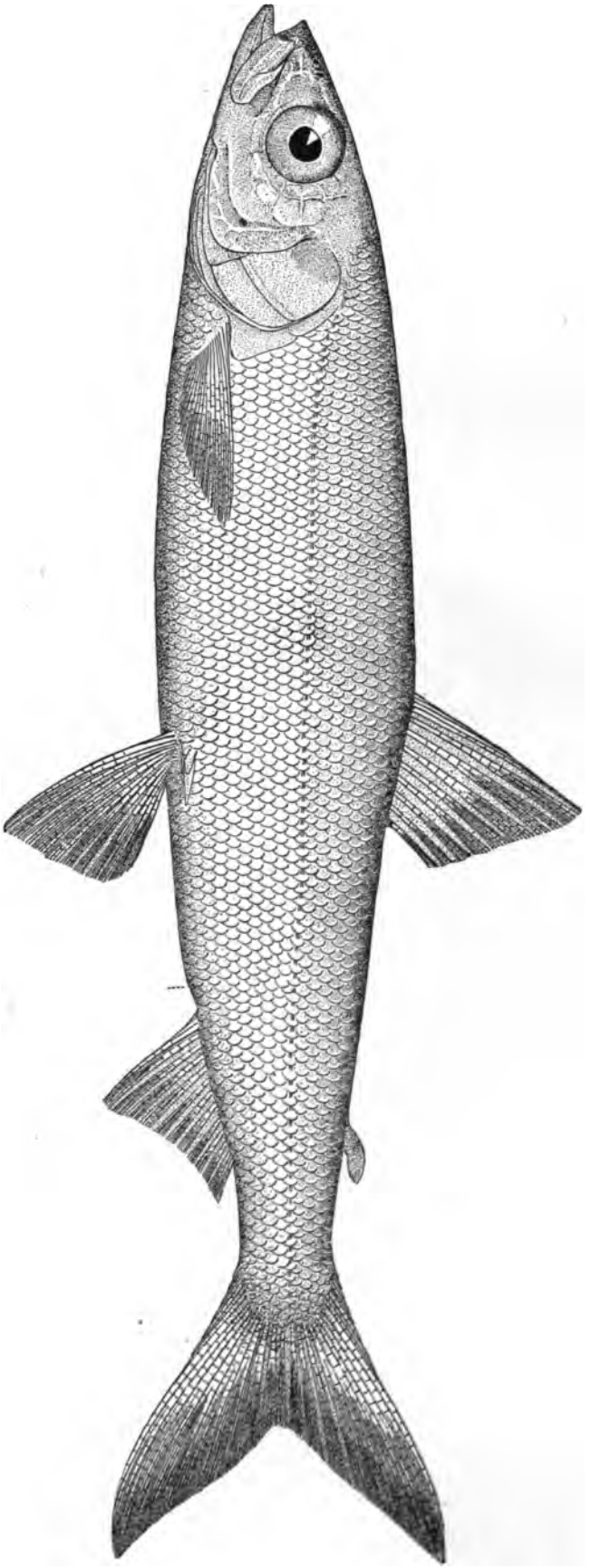
DOROSOMA CEPEDIANUM (Le Sueur). *Mud Shad; Gizzard Shad.*



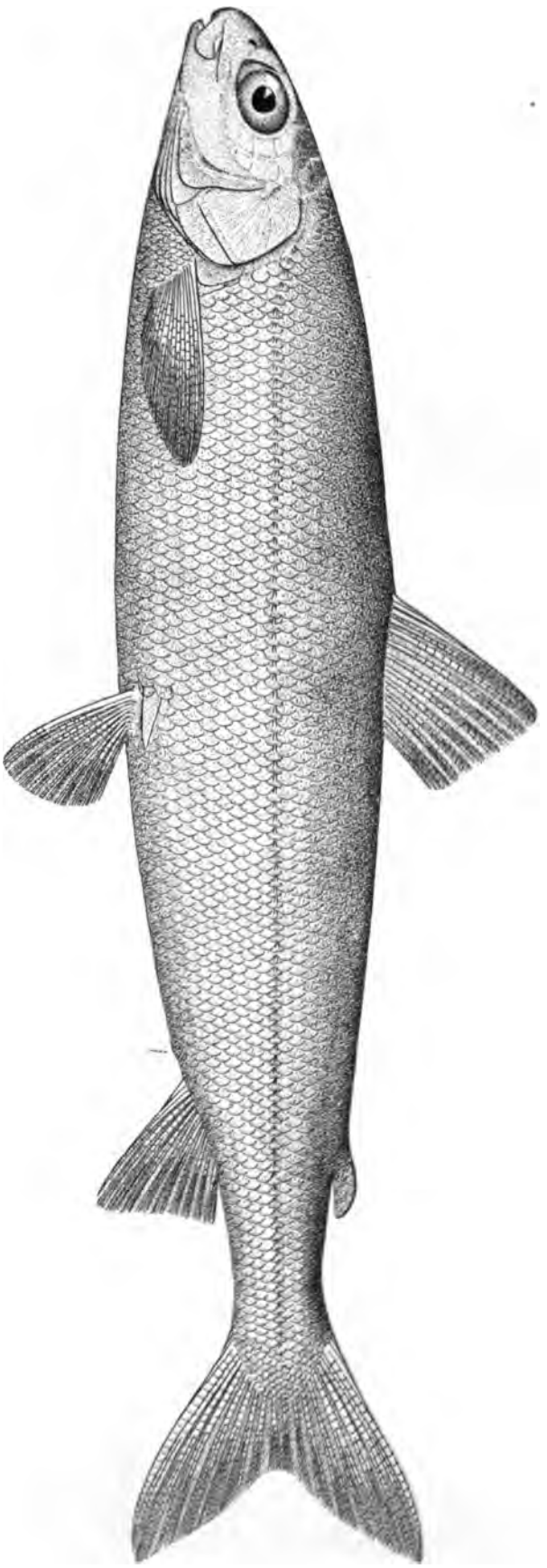
COREGONUS CLUPEIFORMIS (Mitchill). Common Whitefish.



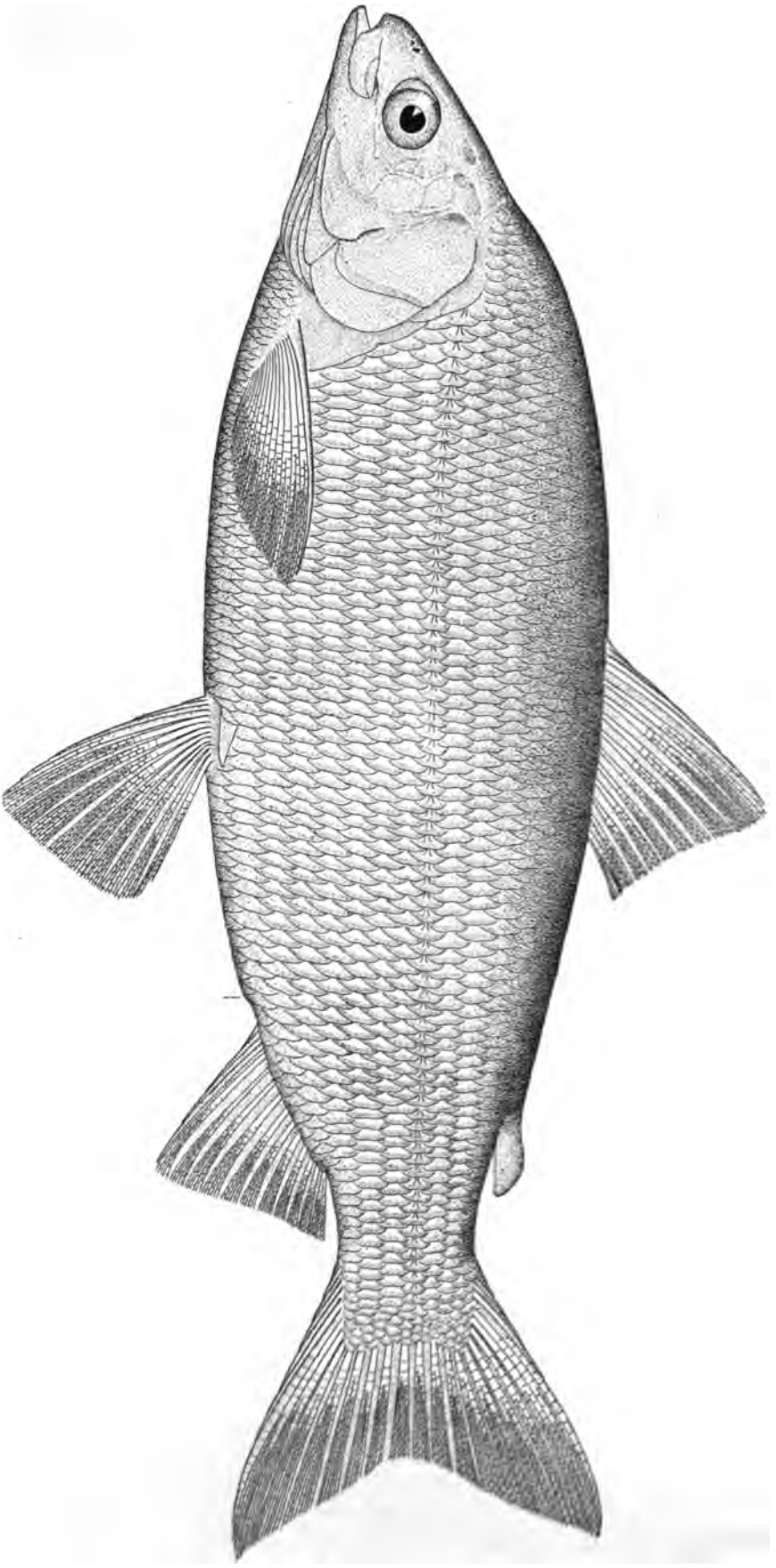
COREGONUS ARTEDI Le Sueur. (Lake Herring.)



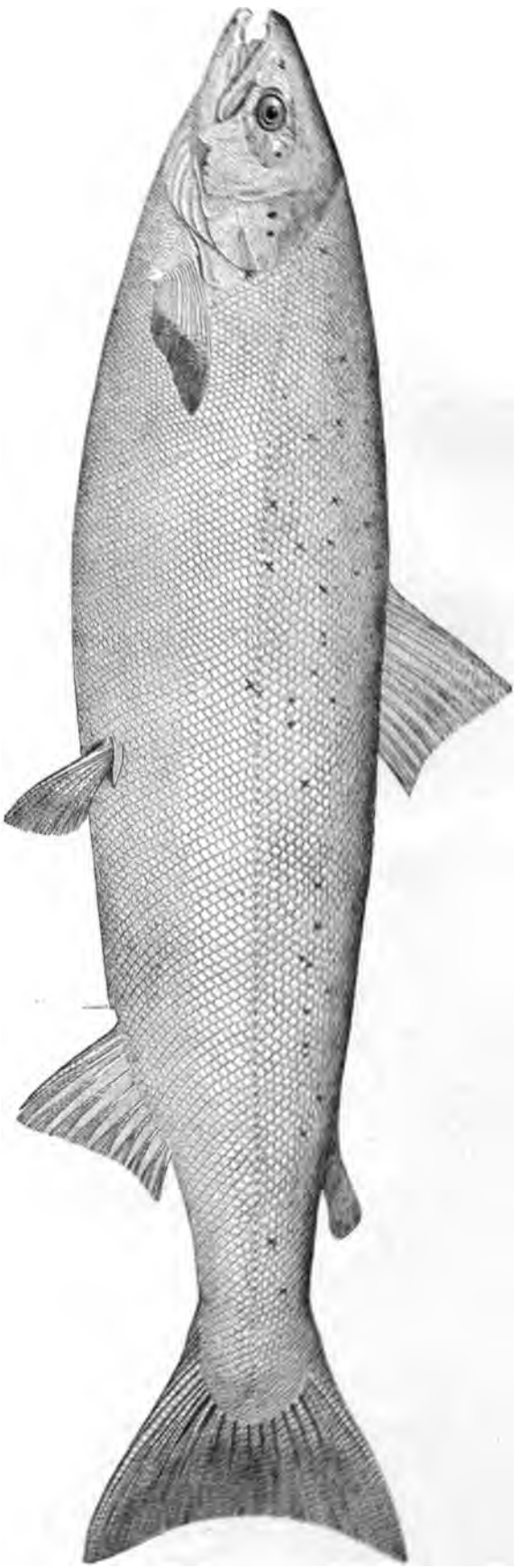
COREGONUS HOYI (Gill). *Hoy's Whitefish; Lake Moon-eye; Long-jaw.*



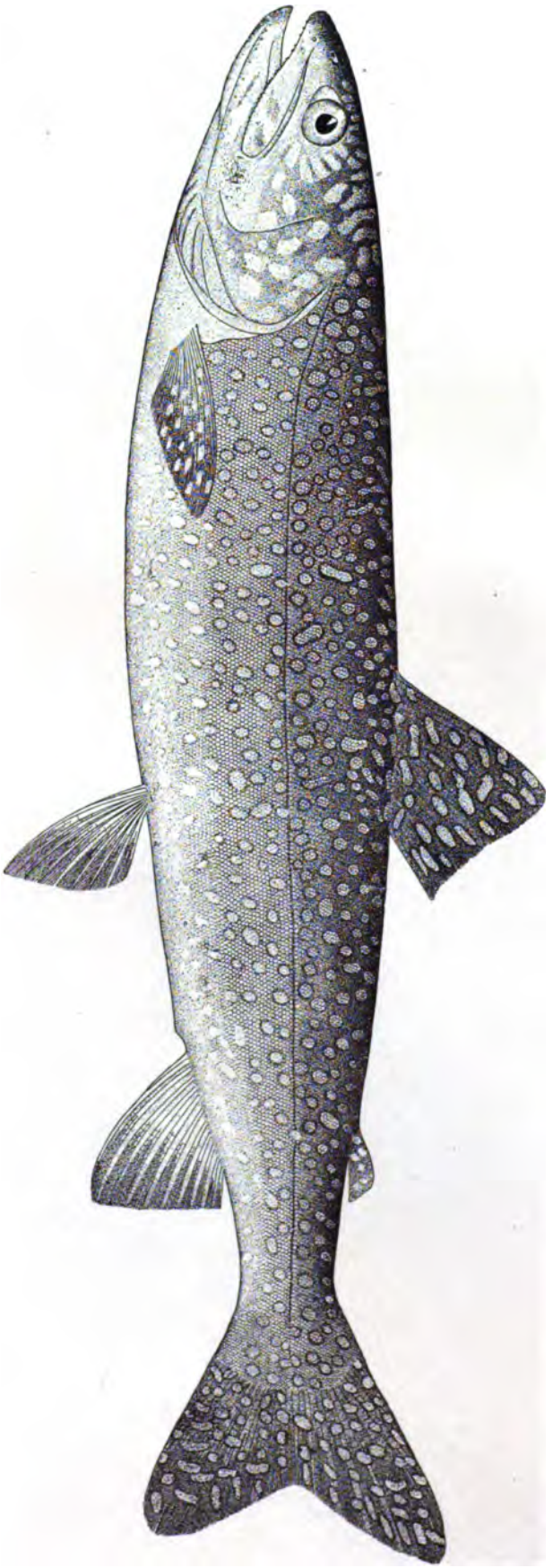
COREGONUS QUADRILATERALIS Richardson. *Round Whitefish; Menominee Whitefish.*



COREGONUS TULLIBEE Richardson. *Tullibee; Mongrel Whitefish.*

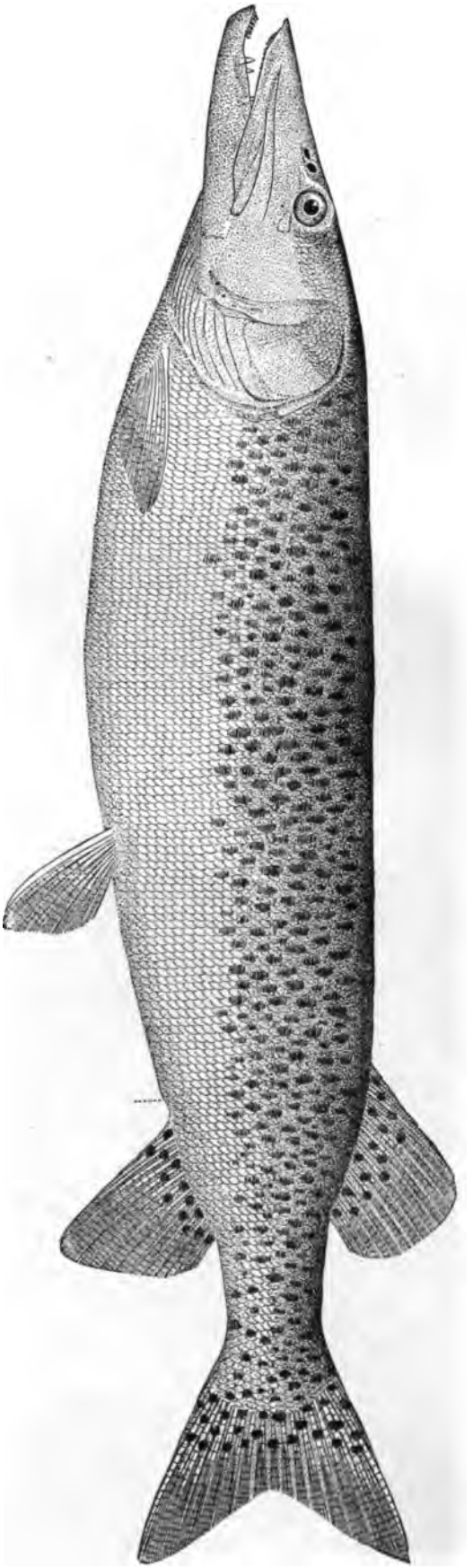


SALMO SALAR Linnæus. *Atlantic Salmon.*



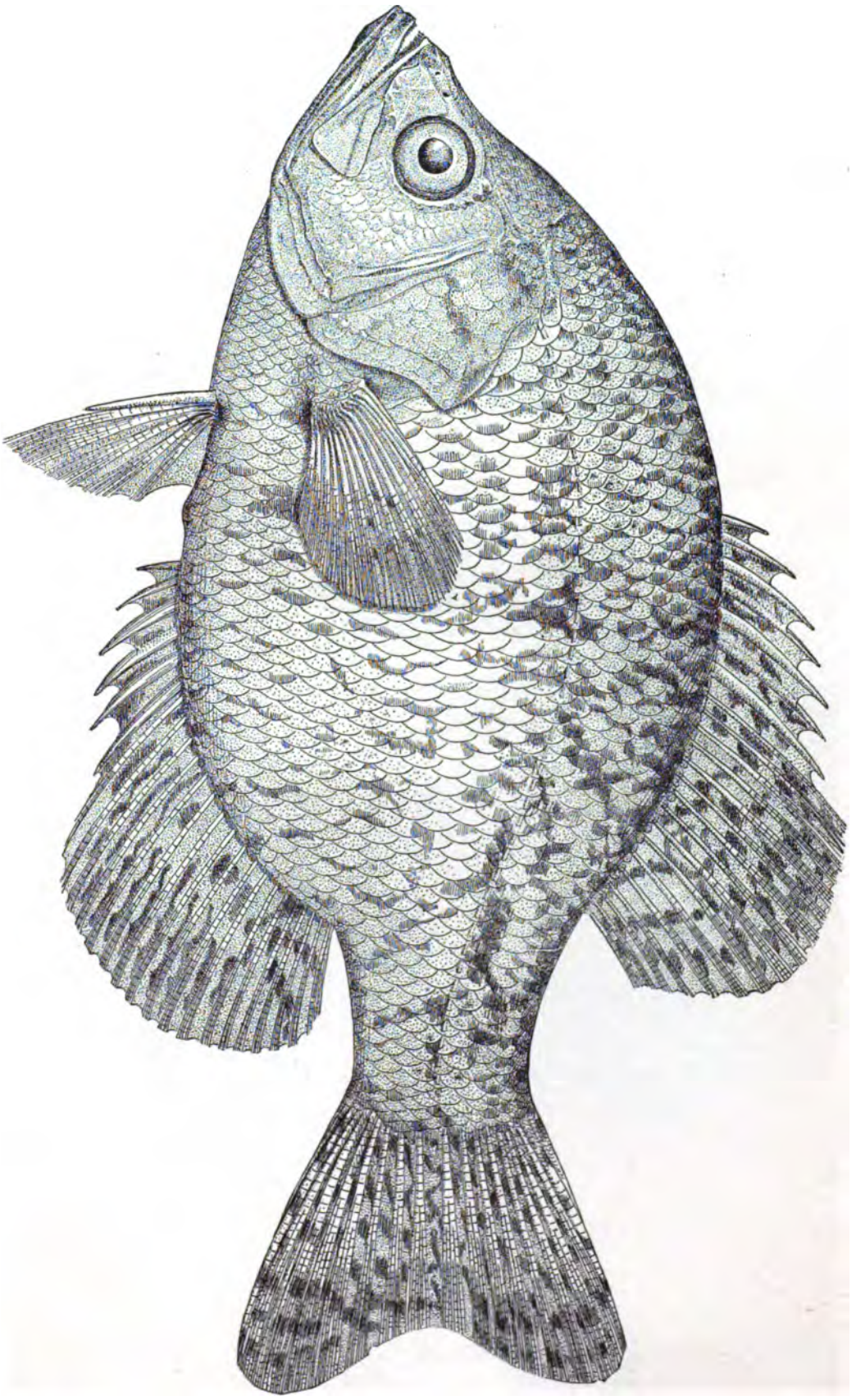
SALVELINUS NAMAYCUSH (Walbaum). *Lake Trout; Salmon Trout.*

ESOX LUCIUS Linnæus. *Pike; Pickerel.*

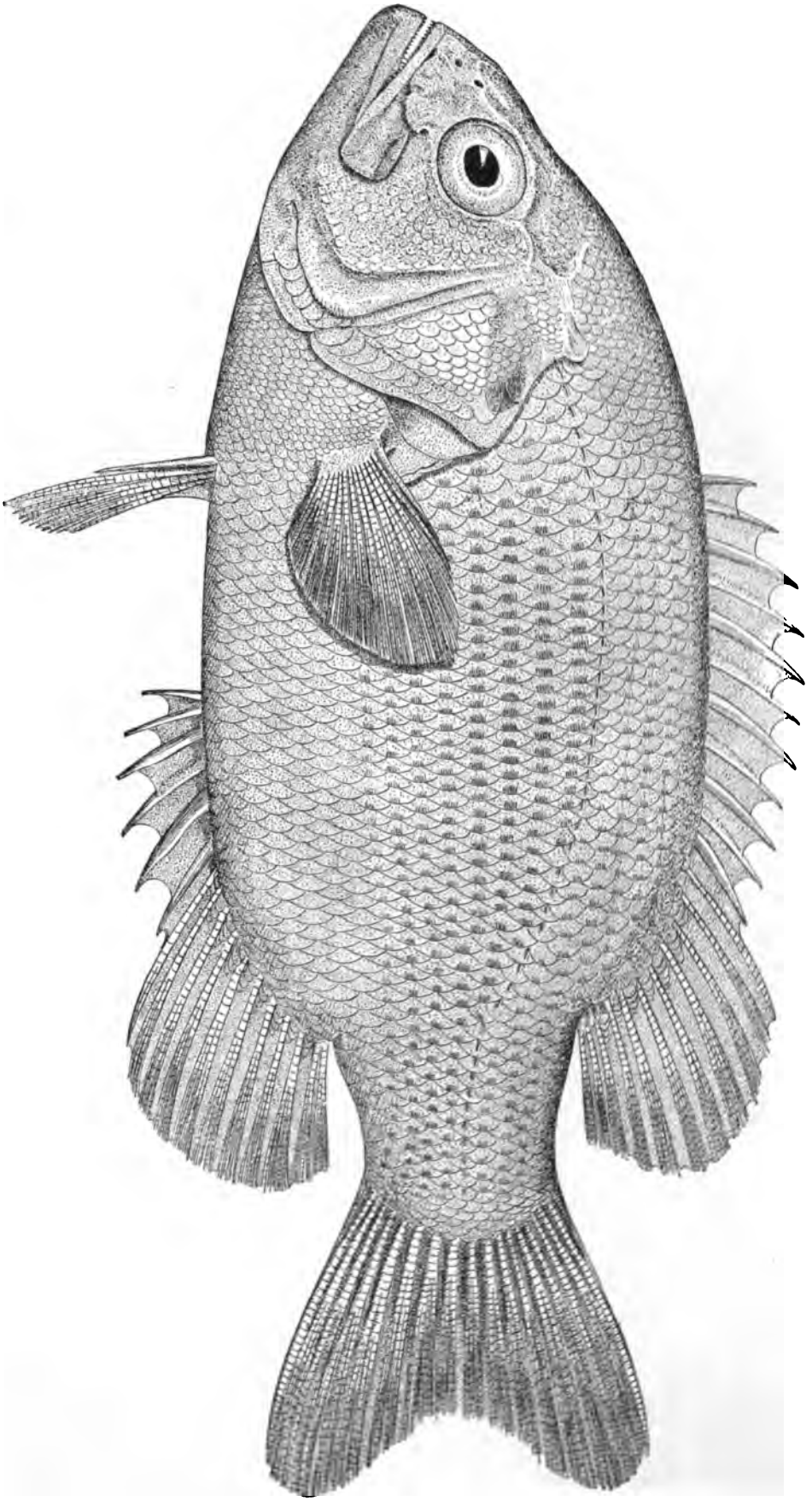


ESOX NOBILIOR Thompson. *Muskellunge.*

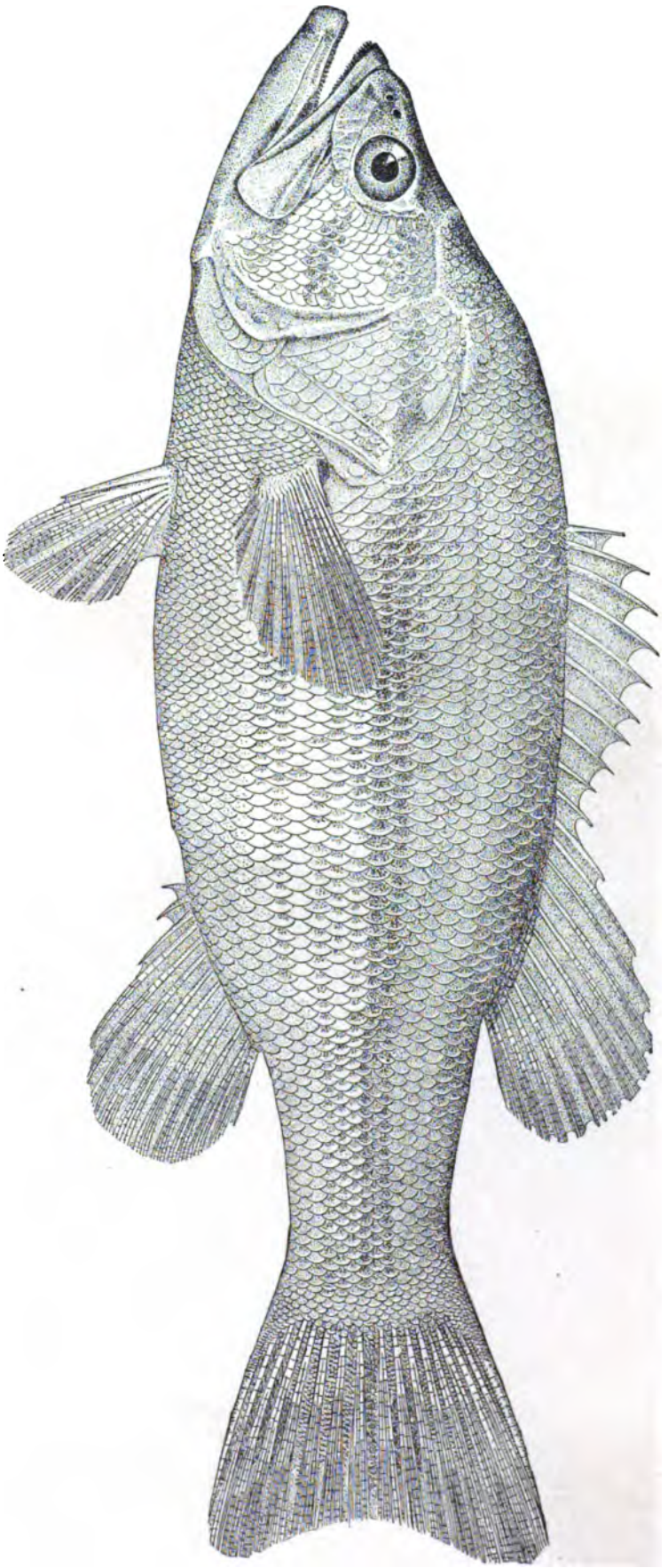
PLATE XLII.



POMOXIS SPAROIDES (Lacépède). *Strawberry Bass; Calico Bass.*

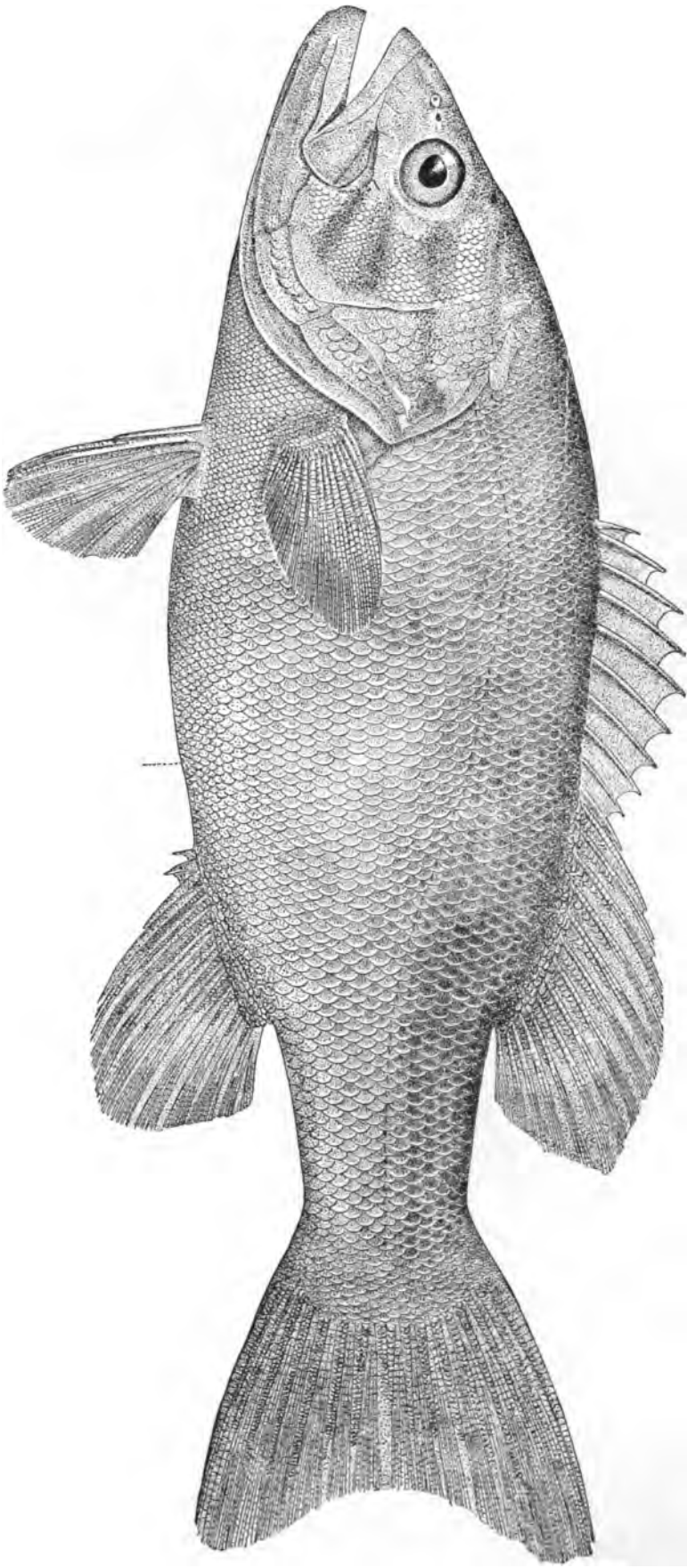


AMBLOPLITES RUPESTRIS (Rafinesque). *Rock Bass*

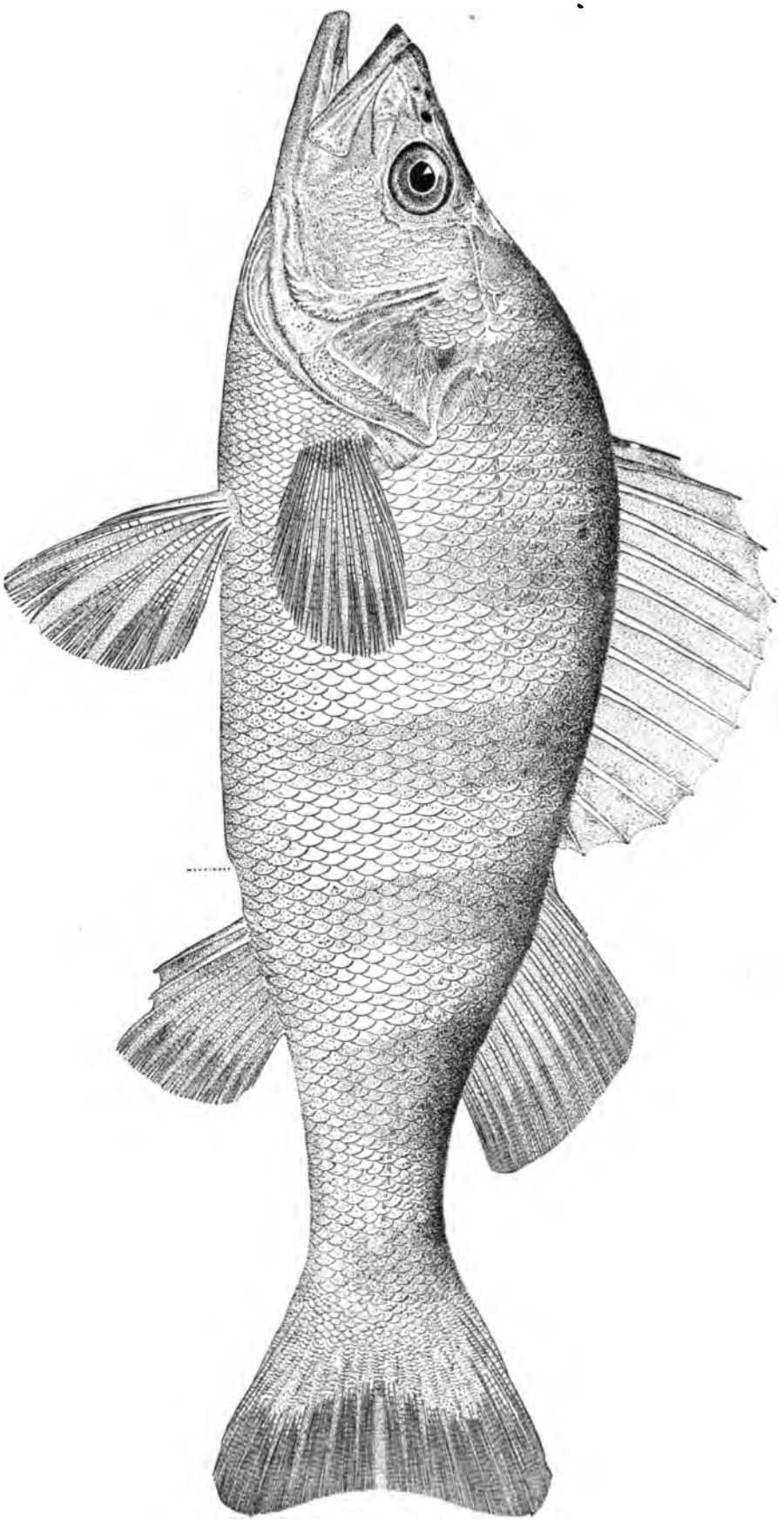


MICROPTERUS SALMOIDES (Lacépède). *Large-mouthed Black Bass; Oswego Bass.*

PLATE XLV.

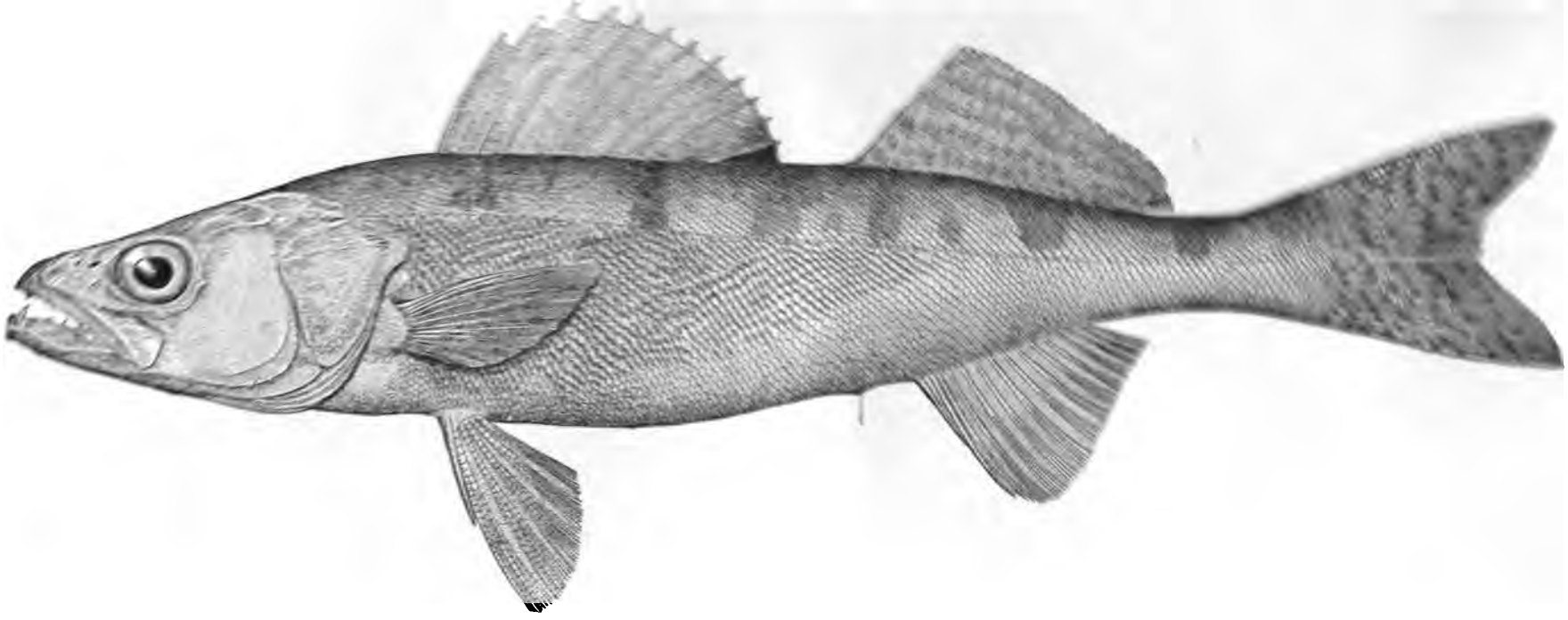


MICROPTERUS DOLOMIEU Lacépède. *Small-mouthed Black Bass.*

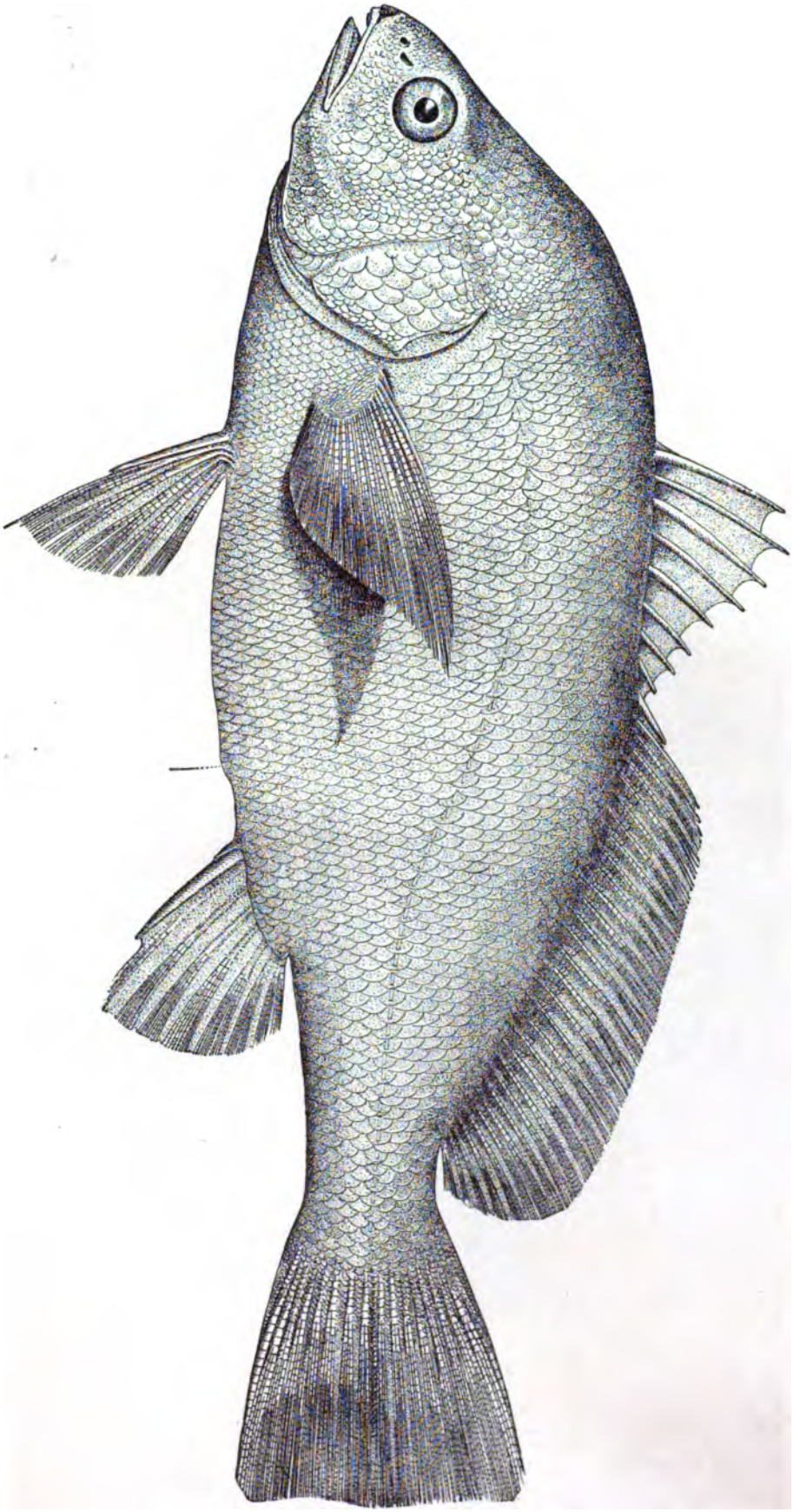


PERCA FLAVESCENS (Mitchill). *Yellow Perch.*

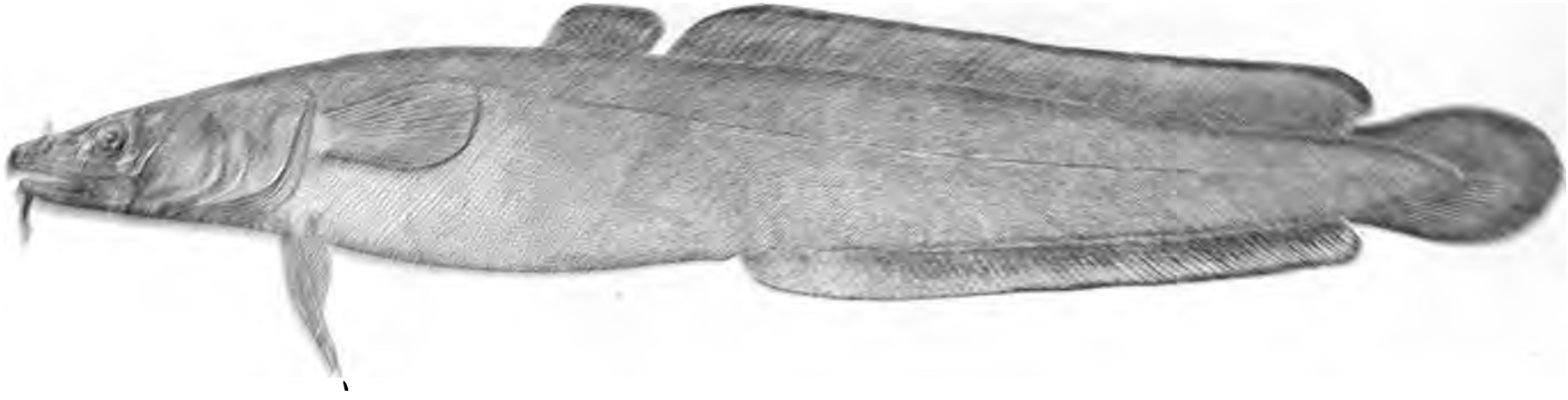
STIZOSTEDION VITREUM (Mitchill). *Wall-eyed Pike; Jaw; Pike Perch.*



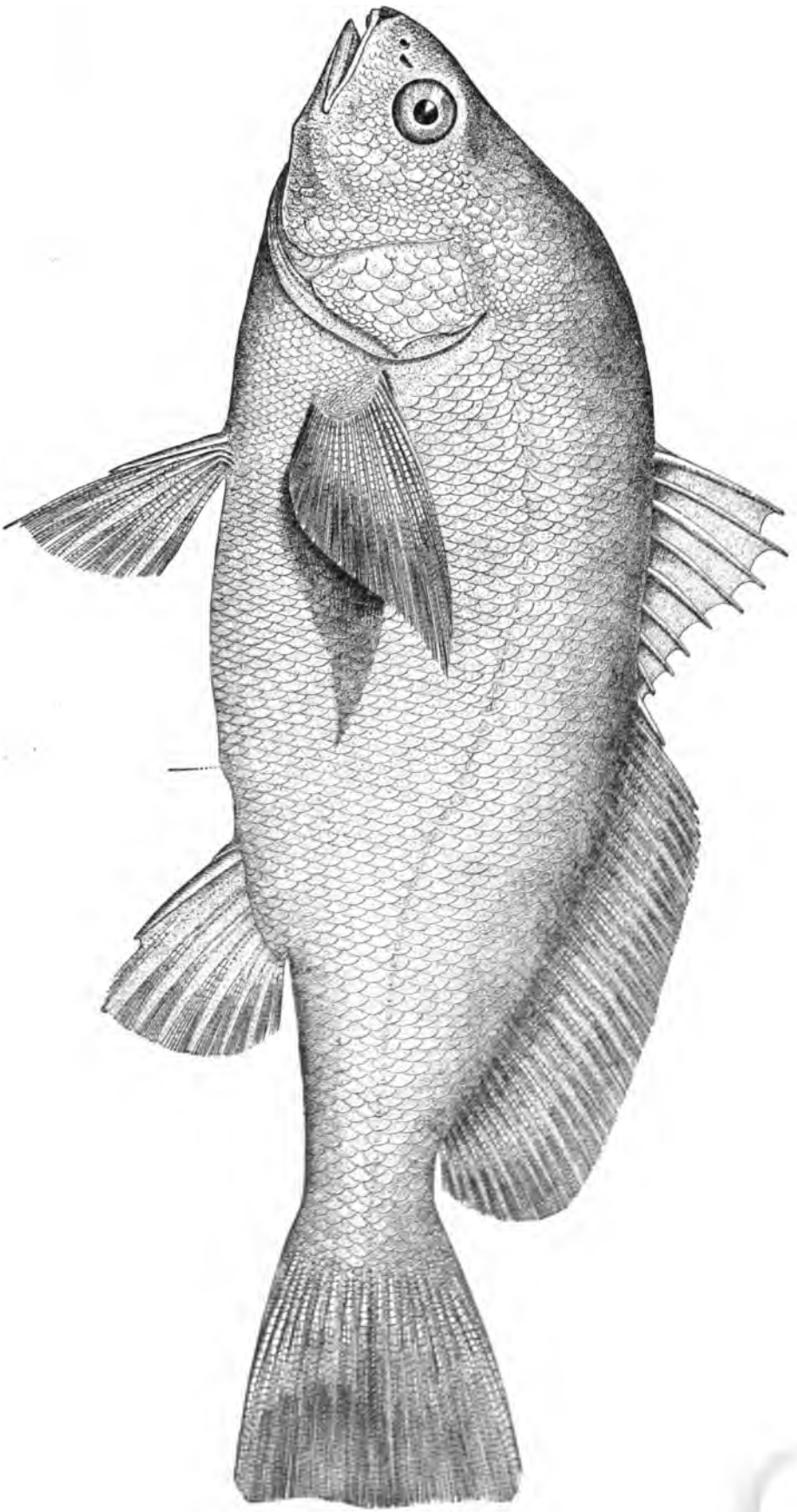
STIZOSTEDION CANADENSE (C. H. Smith). Sauger; Sand Pike.



APLODINOTUS GRUNNIENS (Rafinesque). *Sheepshead; Fresh-water Drum.*



LOTA MACULOSA (Le Sueur). *Ling; Burbot; Lawyer; Fresh-water Cod.*



APLODINOTUS GRUNNIENS (Rafinesque). *Sheepshead; Fresh-water Drum.*

of erosion they never extend far back from the Mississippi River. The surface rises gradually, however, from the southern and eastern borders toward the northern and western, the least elevation above the sea being about 450 feet, and the greatest about 1,500 feet. Iowa is near the center of the best agricultural portion of the country, and the soil, which is from 1 to 2 feet thick on the uplands, becomes very much deeper in the depressions and bottom lands. This soil consists of finely comminuted material, generally strewn with scattered bowlders or rock fragments. Most of the State is undulating or rolling prairie. None of its surface is heavily timbered, and the greater part of the timber land which does occur is confined to the borders of the streams.

The prairie was originally covered with a dense growth of prairie grass and herbaceous plants, which tended to produce a stiff sod. During heavy rains this sod absorbed the water, preventing its direct flow into the rivers, and it reached the latter chiefly by slowly filtering through the soil. The streams were thus relieved from overflow, and were kept from drying up during the summers. I have been informed that many streams, formerly deep and narrow, and abounding in pickerel, bass, and catfishes, have since grown wide and shallow, while the volume of water in them varies greatly in the different seasons, and they are now inhabited only by bullheads, suckers, and a few minnows. The breaking of the native sod for agricultural purposes has especially affected the smaller streams in this respect, while the construction of ditches and the practice of underdraining have had their effects upon the larger ones. Moreover the constant loosening of the soil, in farming, tends to reduce it to that condition in which it is readily transported by the heavy rains to produce muddy currents. To this cause, no doubt, is due the present absence of trout from many of the streams of northeastern Iowa and their marked decrease in other parts of the State. The rainfall in Iowa is not very great and, as it occurs chiefly in the spring, even the larger rivers become reduced in volume during the remainder of the year much beyond the apparent capacity of their basins. There are, however, in the northern and eastern parts of the State many large and beautiful springs, some of which are capable of maintaining considerable streams of water during the entire year. Spring Branch, near Manchester, in which trout are common, and McCloud Run, near Cedar Rapids, are fed by springs of this character. A hatchery was built, a few years ago, at the spring giving rise to McCloud Run, and many trout were hatched and planted there. This station has recently been abandoned, but a few trout are still to be found in the clear, cold water.

Iowa is situated between two of the largest rivers of the continent, being bounded on the east by the Mississippi, and on the west, except at the northwestern corner, by the Missouri. It is drained by many smaller rivers which empty into these main arteries, forming two general systems, the waters of which flow nearly at right angles to each other. Those tributary to the Mississippi trend, in a general way, southeasterly; and those tributary to the Missouri, southwesterly. The northern boundary of the State lies near the watershed between the tributaries of the Minnesota River and the streams which drain Iowa. Most of the rivers of this State, therefore, have their origin within its borders, a few, however, rising in southern Minnesota; and, except a limited number whose sources are in the southern part of the State, all terminate within its limits. The affluents of the Mississippi drain a little more than two-thirds of the area of the State; among them are its largest and most important rivers.

The streams of southwestern Iowa have usually very muddy bottoms, while those elsewhere, having stronger currents, are generally characterized by sandy, gravelly, or rocky bottoms. The former are the least adapted to fish life and are not rich in either species or individuals; with the latter the contrary is the rule.

There are within the limits of the State a few lakes of moderate size; these are situated on or near some watershed and each is fed by only a few small streams. The most important are Clear, Storm, Spirit, and Okobojis Lakes. Clear Lake is very shallow; Storm and Spirit Lakes are successively somewhat deeper, while Okobojis is by far the deepest of them all.

All of the more important rivers have one or more, sometimes many, dams across them; and few, if any, of these are supplied with fishways. As a rule, the dams are not firmly constructed, and every spring many are washed away, never to be rebuilt. During the spring of 1890 much injury was done to the dams in the northeastern part of the State, where these structures are more common than elsewhere, but in 1891 the region about Cherokee suffered most in this respect. At many places where dams exist the streams widen out above them, forming shallow lakes. These areas contain much swamp vegetation, and seem to have become fairly stocked with bass, pickerel, and sunfishes. The same fishes, I am told, have increased in abundance in such localities since the dams were built.

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As a result of observations, it was found that the temperature of the coldest springs in the State was about 48° F.; but in few streams was the water temperature below 60° F. In nearly all such cases the range was from 70° to 75° F., but it should be taken into consideration that these observations were chiefly confined to the warmer months.

In the following report the fishes are discussed in accordance with each river basin. The streams and lakes examined were as follows:

A. *Drainage of the Mississippi River.*

I. Mississippi River at Muscatine and Davenport.
II. Des Moines River: (1) The main river, at Des Moines, Fort Dodge, and Estherville. (2) Raccoon River, at Perry, Des Moines, and Adel. (3) Beaver Creek. (4) Four-mile Creek. (5) Walnut Creek. (6) Middle River. (7) North River, at Des Moines. (8) Lizard River, at Fort Dodge.
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V. Cedar River: (1) The main river, at Austin (Minn.), Waverly, Palo, Cedar Rapids, Mount Vernon, and West Liberty. (2) Turtle River. (3) Rose Creek, at Austin, Minn. (4) West Fork. (5) Hartgraves Creek, at Dumont. (6) Shellrock Creek, 6 miles southwest of Waverly. (7) Quarter Section Run, 5 miles southeast of Waverly. (8) Dry Creek, 4½ miles west of Palo. (9) Prairie Creek, at Beverly. (10) Indian Creek, near Marion.
VI. Clear Lake.

A. *Drainage of Mississippi River*—Cont'd.

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X. Yellow River: (1) The main river, about 6 miles northeast of Postville. (2) Hickory Creek, about 4 miles northeast of Postville.
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B. *Drainage of the Missouri River.*

I. Missouri River, at Sioux City.
II. Big Sioux River, at Sioux Falls (S. Dak.) and Sioux City.
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IV. Soldier River: East Fork of Soldier River, at Charter Oak.
V. Boyer River, at Arion Station.

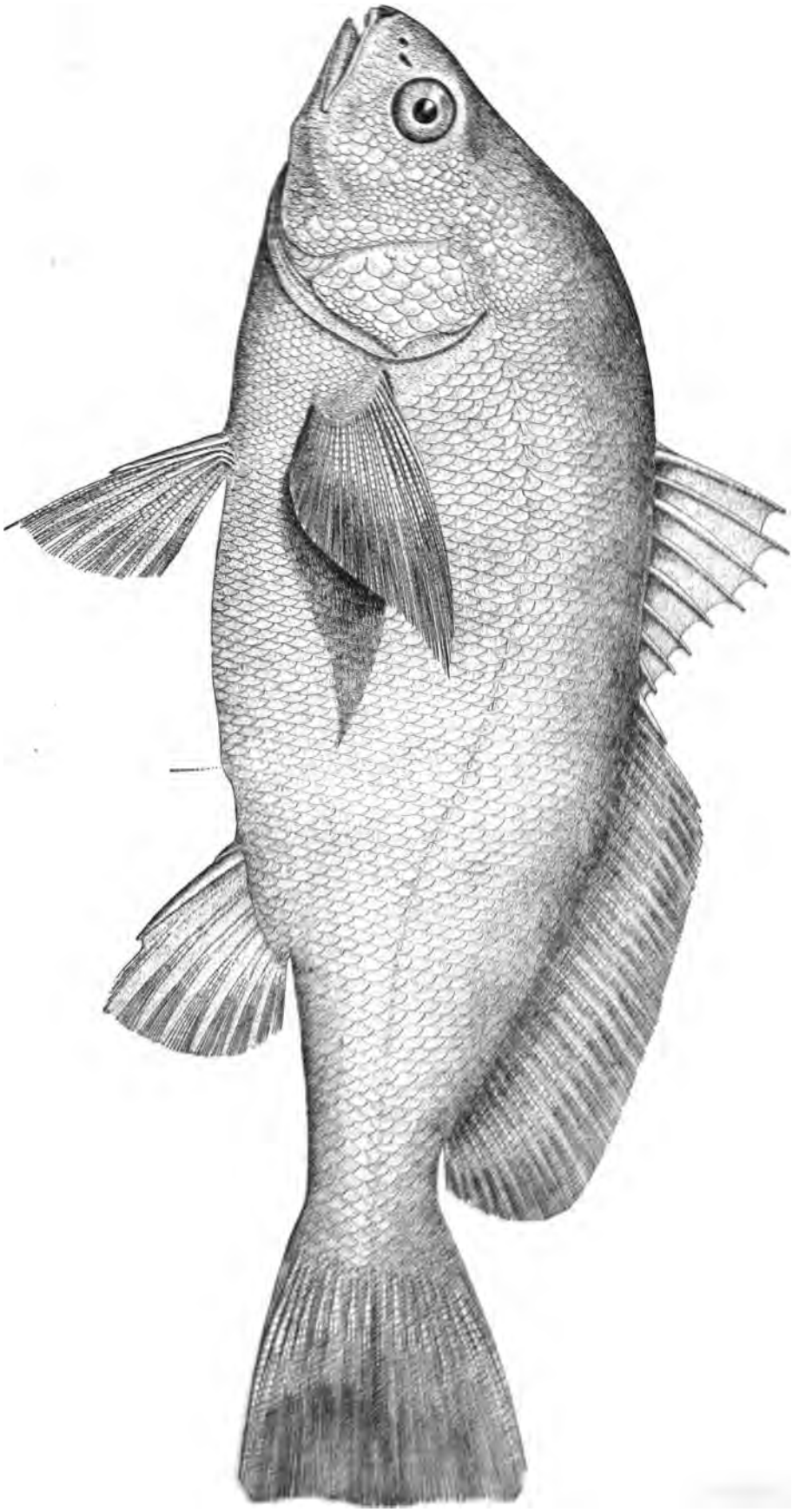
DRAINAGE OF THE MISSISSIPPI RIVER.

I.—THE MISSISSIPPI RIVER.

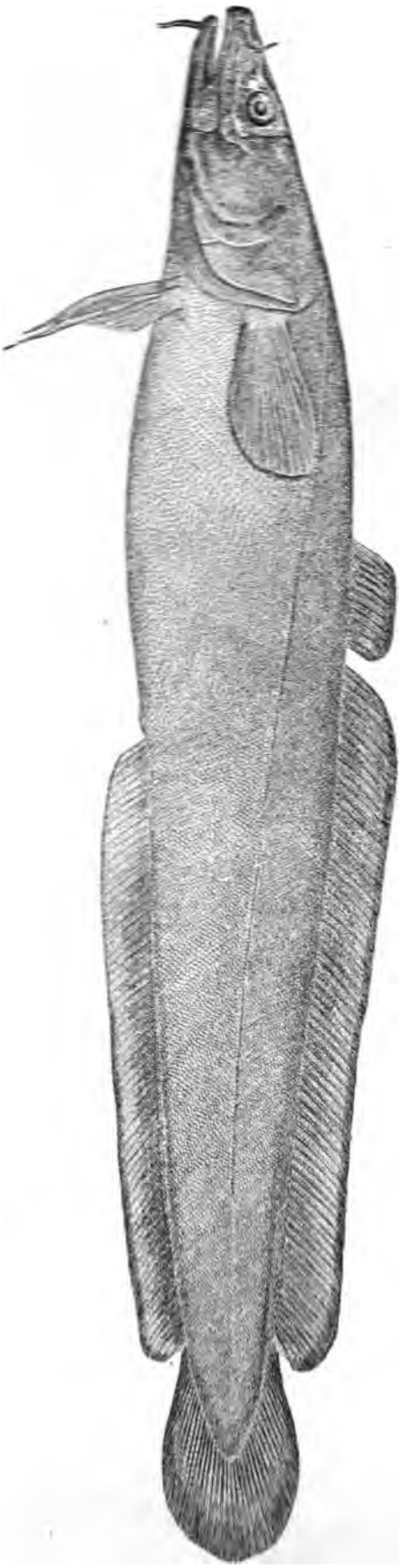
Collections were made in this river at Muscatine and Davenport, the former locality affording by far the best results. There are many bayous at Muscatine, and the river there has generally a sandy bottom and many islands. The best fish market in Iowa is also located in that city. At Davenport there are fewer bayous, and the bottom of the river is more muddy and rocky. One day was spent at Davenport, and three days, at different times, at Muscatine. Mad Creek is a small stream flowing through Muscatine and emptying into the Mississippi. Few specimens were observed except near its mouth. The species enumerated in the following list are from the river at Muscatine unless otherwise expressly stated.

FISHES OF THE MISSISSIPPI RIVER.

1. **Petromyzon concolor** (Kirtland). *Brook lamprey.* Common; parasitic on buffalo-fishes.
2. **Polyodon spathula** (Walbaum). *Paddle-fish; Spoon-bill; Duck-billed cat.* Rare; taken more frequently in the autumn and from the bayous.
3. **Scaphirhynchus platyrhynchus** (Rafinesque). *Shovel-nosed sturgeon.* Rare; seldom found in the market.
4. **Acipenser rubicundus** Le Sueur. *Lake sturgeon.* Not common; more abundant in the spring.
5. **Lepisosteus osseus** (Linnæus). *Common gar-pike; Long-nosed gar; Bill-fish.* Common at both Muscatine and Davenport.
6. **Lepisosteus platystomus** Rafinesque. *Short-nosed gar.* Common.
7. **Amia calva** Linnæus. *Dogfish; Bow-fin; Mudfish.* Common; but seldom taken from the river.
8. **Ictalurus furcatus** (Cuv. and Val.). *Fork-tailed cat.* Rare; not observed by the writer.
9. **Ictalurus punctatus** (Rafinesque). *Channel cat; White cat; Silver cat.* Common at both Muscatine and Davenport, and many seen in the markets at the former place.
10. **Ameiurus nigricans** (Le Sueur). *Mississippi catfish.* Rare; specimens weighing 50 pounds are occasionally captured.
11. **Ameiurus melas** (Rafinesque). *Bullhead.* Abundant at Muscatine; common at Davenport.
12. **Ameiurus nebulosus** (Le Sueur). *Common catfish.* Abundant.
13. **Leptops olivaris** (Rafinesque). *Mud cat; Flathead cat.* Common.
14. **Noturus gyrinus** (Mitchill). *Stone cat.* Rare.
15. **Ictiobus cyprinella** (Cuv. and Val.). *Red-mouthed buffalo.* Common; usually taken from the bayous.
16. **Ictiobus urus** (Agassiz). *Big-mouthed buffalo.* Common.
17. **Ictiobus bubalus** (Rafinesque). *Small-mouthed buffalo.* Common.
18. **Carpiodes velifer** (Rafinesque). *Quillback; Carp sucker.* Very abundant at Muscatine; common at Davenport.
19. **Cycleptus elongatus** (Le Sueur). *Blackhorse.* Not common.
20. **Catostomus teres** (Mitchill). *Common sucker.* Abundant.
21. **Minytrema melanops** (Rafinesque). *Striped sucker.* Rare; taken from the bayous.
22. **Moxostoma duquesnei** (Le Sueur). *Common redhorse.* Common.
23. **Hybognathus nuchalis** Agassiz. *Silvery minnow.* Common alongshore and at Davenport; abundant at mouth of Mad Creek.
24. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow.* Common.
25. **Cliola vigilax** (Baird and Girard). *Silver-fin.* Rare at the mouth of Mad Creek; common at Davenport.
26. **Notropis deliciosus** (Girard). Rare; taken at mouth of Mad Creek.
27. **Notropis gilberti** Jordan and Meek. Common at mouth of Mad Creek.
28. **Notropis whipplei** (Girard). Rare.
29. **Notropis jejunus** (Forbes). Common at Davenport.
30. **Notropis dilectus** (Girard). *Emerald minnow.* Common at mouth of Mad Creek; not common at Davenport.
31. **Hybopsis storerianus** (Kirtland). *Spawn-eater.* Common at mouth of Mad Creek; rare at Davenport.
32. **Semotilus atromaculatus** (Mitchill). *Horned dace.* Rare.
33. **Notemigonus chrysoleucus** (Mitchill). *Roach; Golden shiner; Bream.* Rare; taken in bayous and at Davenport.
34. **Clupea chrysochloris** Rafinesque. *Golden shad; Skipjack.* Common at Muscatine and Davenport.
35. **Dorosoma cepedianum** (Le Sueur). *Gizzard shad; Hickory shad; Mud shad.* Common, especially in the muddy bayous and at Davenport.
36. **Salvelinus fontinalis** (Mitchill). *Brook trout.* On May 14, 1889, a specimen was taken from Mad Creek, at Muscatine, Iowa; it is preserved in the Muscatine Academy of Sciences; it was no doubt a straggler from some of the spring brooks farther north.
37. **Lucius vermiculatus** (Le Sueur). *Little pickerel.* Common in grassy bayous.



APLODINOTUS GRUNNIENS (Rafinesque). *Sheepshead; Fresh-water Drum.*



LOTA MACULOSA (Le Sueur). *Lings; Burbot; Lawyer; Freshwater Cusk.*

7.—A REPORT UPON THE FISHES OF IOWA, BASED UPON OBSERVATIONS AND COLLECTIONS MADE DURING 1889, 1890, AND 1891.

BY SETH EUGENE MEEK.

INTRODUCTION.

In August, 1884, Dr. David S. Jordan, now of Palo Alto, California, accompanied by the writer, made a collection of fishes in the southern part of Iowa in the interest of the U. S. Fish Commission and the U. S. National Museum. This was practically the first step taken toward a comprehensive study of the ichthyological features of Iowa. The work was not, however, resumed until 1889, when, under the direction of the U. S. Fish Commissioner, the writer began an exhaustive examination of all the streams and lakes within the borders of the State. This investigation was continued until July, 1891, and the present paper is based upon the collections and observations made during that period of about two and a half years.

In the conduct of my field work I have been placed under many obligations to Mr. C. J. Ives, president of the Burlington, Cedar Rapids and Northern Railroad, and to Mr. Joseph White, superintendent of the water supply of the same corporation, for special facilities in the way of transportation and for other favors, which have enabled me to extend my studies beyond the limit of means at my disposal. Valuable assistance has been received from Prof. R. E. Call, of Des Moines; from Prof. Osborn, of Ames, and from Prof. C. C. Nutting, of Iowa City, who have also obtained for me the privilege of examining the collections of fishes belonging to the respective institutions with which they are connected. I am also greatly indebted to Mr. B. F. Shaw, formerly State fish commissioner, and to Dr. David S. Jordan and Prof. Charles H. Gilbert, the latter especially for their kind assistance in regard to the identification of rare and difficult species. Prof. Percy B. Burnett, of Lincoln, Nebraska, and my students, Mr. W. T. Jackson and Mr. E. P. Boynton, have rendered efficient services in connection with the field expeditions, the first mentioned having accompanied me during much of the summer of 1890.

Iowa has a comparatively level surface over its entire extent, being nowhere traversed by mountain ranges and having no pronounced hills except in the northeastern part. In this corner of the State the hills and cliffs sometimes attain an elevation of over 300 feet above the general level of the surrounding country, but being products

of erosion they never extend far back from the Mississippi River. The surface rises gradually, however, from the southern and eastern borders toward the northern and western, the least elevation above the sea being about 450 feet, and the greatest about 1,700 feet. Iowa is near the center of the best agricultural portion of the country, and the soil, which is from 1 to 2 feet thick on the uplands, becomes very much deeper in the depressions and bottom lands. This soil consists of finely comminuted material, generally strewn with scattered bowlders or rock fragments. Most of the State is undulating or rolling prairie. None of its surface is heavily timbered, and the greater part of the timber land which does occur is confined to the borders of the streams.

The prairie was originally covered with a dense growth of prairie grass and herbaceous plants, which tended to produce a stiff sod. During heavy rains this sod absorbed the water, preventing its direct flow into the rivers, and it reached the latter chiefly by slowly filtering through the soil. The streams were thus relieved from overflow, and were kept from drying up during the summers. I have been informed that many streams, formerly deep and narrow, and abounding in pickerel, bass, and catfishes, have since grown wide and shallow, while the volume of water in them varies greatly in the different seasons, and they are now inhabited only by bullheads, suckers, and a few minnows. The breaking of the native sod for agricultural purposes has especially affected the smaller streams in this respect, while the construction of ditches and the practice of underdraining have had their effects upon the larger ones. Moreover the constant loosening of the soil, in farming, tends to reduce it to that condition in which it is readily transported by the heavy rains to produce muddy currents. To this cause, no doubt, is due the present absence of trout from many of the streams of northeastern Iowa and their marked decrease in other parts of the State. The rainfall in Iowa is not very great and, as it occurs chiefly in the spring, even the larger rivers become reduced in volume during the remainder of the year much beyond the apparent capacity of their basins. There are, however, in the northern and eastern parts of the State many large and beautiful springs, some of which are capable of maintaining considerable streams of water during the entire year. Spring Branch, near Manchester, in which trout are common, and McCloud Run, near Cedar Rapids, are fed by springs of this character. A hatchery was built, a few years ago, at the spring giving rise to McCloud Run, and many trout were hatched and planted there. This station has recently been abandoned, but a few trout are still to be found in the clear, cold water.

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The streams of southwestern Iowa have usually very muddy bottoms, while those elsewhere, having stronger currents, are generally characterized by sandy, gravelly, or rocky bottoms. The former are the least adapted to fish life and are not rich in either species or individuals; with the latter the contrary is the rule.

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2. **Polyodon spathula** (Walbaum). *Paddle-fish; Spoon-bill; Duck-billed cat.* Rare; taken more frequently in the autumn and from the bayous.
3. **Scaphirhynchus platyrhynchus** (Rafinesque). *Shovel-nosed sturgeon.* Rare; seldom found in the market.
4. **Acipenser rubicundus** Le Sueur. *Lake sturgeon.* Not common; more abundant in the spring.
5. **Lepisosteus osseus** (Linnæus). *Common gar-pike; Long-nosed gar; Bill-fish.* Common at both Muscatine and Davenport.
6. **Lepisosteus platystomus** Rafinesque. *Short-nosed gar.* Common.
7. **Amia calva** Linnæus. *Dogfish; Bow-fin; Mudfish.* Common; but seldom taken from the river.
8. **Ictalurus furcatus** (Cuv. and Val.). *Fork-tailed cat.* Rare; not observed by the writer.
9. **Ictalurus punctatus** (Rafinesque). *Channel cat; White cat; Silver cat.* Common at both Muscatine and Davenport, and many seen in the markets at the former place.
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15. **Ictiobus cyprinella** (Cuv. and Val.). *Red-mouthed buffalo.* Common; usually taken from the bayous.
16. **Ictiobus urus** (Agassiz). *Big-mouthed buffalo.* Common.
17. **Ictiobus bubalus** (Rafinesque). *Small-mouthed buffalo.* Common.
18. **Carpiodes velifer** (Rafinesque). *Quillback; Carp sucker.* Very abundant at Muscatine; common at Davenport.
19. **Cycleptus elongatus** (Le Sueur). *Blackhorse.* Not common.
20. **Catostomus teres** (Mitchill). *Common sucker.* Abundant.
21. **Minytrema melanops** (Rafinesque). *Striped sucker.* Rare; taken from the bayous.
22. **Moxostoma duquesnei** (Le Sueur). *Common redhorse.* Common.
23. **Hybognathus nuchalis** Agassiz. *Silvery minnow.* Common alongshore and at Davenport; abundant at mouth of Mad Creek.
24. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow.* Common.
25. **Cliola vigilax** (Baird and Girard). *Silver-fin.* Rare at the mouth of Mad Creek; common at Davenport.
26. **Notropis deliciosus** (Girard). Rare; taken at mouth of Mad Creek.
27. **Notropis gilberti** Jordan and Meek. Common at mouth of Mad Creek.
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29. **Notropis jejunus** (Forbes). Common at Davenport.
30. **Notropis dilectus** (Girard). *Emerald minnow.* Common at mouth of Mad Creek; not common at Davenport.
31. **Hybopsis storerianus** (Kirtland). *Spawn-eater.* Common at mouth of Mad Creek; rare at Davenport.
32. **Semotilus atromaculatus** (Mitchill). *Horned dace.* Rare.
33. **Notemigonus chrysoleucus** (Mitchill). *Roach; Golden shiner; Bream.* Rare; taken in bayous and at Davenport.
34. **Clupea chrysochloris** Rafinesque. *Golden shad; Skipjack.* Common at Muscatine and Davenport.
35. **Dorosoma cepedianum** (Le Sueur). *Gizzard shad; Hickory shad; Mud shad.* Common, especially in the muddy bayous and at Davenport.
36. **Salvelinus fontinalis** (Mitchill). *Brook trout.* On May 14, 1889, a specimen was taken from Mad Creek, at Muscatine, Iowa; it is preserved in the Muscatine Academy of Sciences; it was no doubt a straggler from some of the spring brooks farther north.
37. **Lucius vermiculatus** (Le Sueur). *Little pickerel.* Common in grassy bayous.

38. **Lucius lucius** (Linnæus). *Pike; Northern pickerel.* Very common, especially in the large grassy bayous.
39. **Lucius masquinongy** (Mitchill). *Muskellunge.* Rare.
40. **Anguilla chrysypa** Rafinesque. *Eel.* Rare; no specimens were observed by the writer.
41. **Labidesthes sicculus** Cope. *Brook silverside.* Common at mouth of Mad Creek; rare at Davenport.
42. **Pomoxis sparoides** (Lacépède). *Calico bass; Grass bass; Strawberry bass.* Abundant, especially in grassy bayous.
43. **Pomoxis annularis** Rafinesque. *Crappie; Bachelor.* Common; found with the preceding, but in less numbers; not common at Davenport.
44. **Ambloplites rupestris** (Rafinesque). *Rock bass; Red-eye; Goggle-eye.* Very common.
45. **Chænobryttus gulosus** (Cuv. and Val.). *War-mouth; Red-eyed bream.* Very common, especially in the bayous; common at Davenport.
46. **Lepomis cyanellus** (Rafinesque). *Green sunfish.* Very abundant at Muscatine; common at Davenport.
47. **Lepomis humilis** (Girard). *Red-spotted sunfish.* Common at Davenport.
48. **Lepomis pallidus** (Mitchill). *Blue sunfish.* Abundant; common at Davenport.
49. **Lepomis megalotis** (Rafinesque). *Long-eared sunfish.* Common.
50. **Lepomis gibbosus** (Linnæus). *Common sunfish.* Very common.
51. **Micropterus dolomieu** Lacépède. *Small-mouthed black bass.* Abundant at Muscatine; not common at Davenport.
52. **Micropterus salmoides** (Lacépède). *Large-mouthed black bass.* Abundant; small specimens found in bayous on the Illinois side of the river at Muscatine; not common at Davenport.
53. **Etheostoma pellucidum clarum** (Jordan and Meek). *Sand darter.* Rare at Davenport.
54. **Etheostoma shumardi** (Girard). A few specimens taken from the river.
55. **Etheostoma phoxocephalum** Nelson. Rare.
56. **Perca flavescens** (Mitchill). *Yellow perch.* Very common.
57. **Stizostedion vitreum** (Mitchill). *Wall-eyed pike; Jack salmon.* Very common.
58. **Stizostedion canadense** (C. H. Smith). *Sauger; Sand pike.* Less common than the preceding.
59. **Roccus chrysops** Rafinesque. *White bass.* Common at both Muscatine and Davenport.
60. **Morone interrupta** Gill. *Yellow bass.* Not common.
61. **Aplodinotus grunniens** Rafinesque. *Fresh-water drum; White perch.* Common at Muscatine and Davenport.
62. **Lota lota maculosa** (Le Sueur). *Burbot; Lake lawyer.* Not common.

II.—THE DES MOINES RIVER AND ITS TRIBUTARIES.

This is the largest river basin within the State, occupying a large part of its central area. The main river was visited at Estherville, Fort Dodge, and Des Moines. At Estherville it is little more than a small creek, with sandy or gravelly bottom and much vegetation. At Fort Dodge the river is large, but its physical characteristics are about the same as at Estherville. At Des Moines the bottom is sandy, with considerable mud and but few rocks.

Lizard Creek, near Fort Dodge, is a small stream with very rocky bottom. Its current is not swift and it becomes nearly dry during the summer. The Raccoon River is a large western tributary of the Des Moines. At Perry it has a sandy bottom with little mud and rocks, while at Des Moines its characteristics are about the same, but it is larger. Beaver and Walnut creeks, near Des Moines, are small streams, with muddy and sandy bottoms, which become nearly dry during the summer. The other streams near Des Moines mentioned in this paper were not visited by the writer. The specimens examined from them were collected by Prof. Call, of Des Moines, and are mostly in the Des Moines High School. In the following list all citations of the Raccoon River refer only to that river at Des Moines.

FISHES OF THE DES MOINES RIVER AND ITS TRIBUTARIES.

1. **Petromyzon concolor** (Kirtland). *Brook lamprey.* Des Moines, rare. Infraoral cusps 9 or 10.
2. **Lepisosteus osseus** (Linnæus). *Common gar-pike; Long-nosed gar; Bill-fish.* Raccoon River, Des Moines; Adel.
3. **Ictalurus punctatus** (Rafinesque). *Channel cat; White cat; Silver cat.* Des Moines (Raccoon River), common; Middle River; Adel; Fort Dodge, abundant; Lizard Creek, common; Perry, common; Des Moines, rare; North River, Walnut Creek, Beaver Creek, rare.
4. **Ameiurus melas** (Rafinesque). *Bullhead.* Des Moines (Raccoon River), abundant in bayous; Fort Dodge, not common; Walnut Creek, Estherville, Perry, North River, Adel, Walnut and Beaver creeks, rare.
5. **Noturus exilis** Nelson. *Stone cat.* Perry, rare.
6. **Noturus gyrinus** (Mitchill). *Stone cat.* Estherville and Raccoon River, Fort Dodge, and Des Moines, rare.
7. **Carpiodes velifer** (Rafinesque). *Quillback; Carp-sucker.* Lizard Creek, very abundant; Des Moines (Raccoon River) and Perry, abundant; Des Moines and Fort Dodge, common; Beaver and Walnut creeks, rare; Adel, Middle River and North River.
8. **Moxostoma anisurum** (Le Sueur). Lizard Creek and Fort Dodge, not common.
9. **Moxostoma duquesnei** (Le Sueur). *Redhorse.* Lizard Creek and Perry, abundant; Des Moines (Raccoon River), Des Moines, Estherville, Fort Dodge, common; Beaver Creek, rare; Middle River, Adel.
10. **Placopharynx carinatus** Cope. *Big-jawed sucker.* Perry and Raccoon River, common; Adel.
11. **Catostomus teres** (Mitchill). *Common sucker.* Des Moines, Raccoon River, Fort Dodge, and Estherville, common; Walnut Creek, Beaver Creek, Lizard Creek, and Perry, rare; Middle River, Adel, North River.
12. **Catostomus nigricans** Le Sueur. *Hog sucker; Stone-roller; Hog mullet.* Perry, abundant; Fort Dodge, common; Beaver Creek, Des Moines, and Raccoon River, rare; Adel, Middle River.
13. **Campostoma anomalum** (Rafinesque). *Stone-lugger; Stone-roller.* Raccoon River and Lizard Creek, not common; Beaver and Walnut creeks, Des Moines. Fort Dodge, and Perry, rare; Four-mile Creek, Adel, North River, Middle River.
14. **Chrosomus erythrogaster** Rafinesque. *Red-bellied minnow.* Walnut Creek, rare.
15. **Hybognathus nuchalis** Agassiz. *Silvery minnow.* Raccoon River and Perry, abundant; Beaver Creek, Walnut Creek, Des Moines, and Fort Dodge, common; Lizard Creek, Adel.
16. **Hybognathus nuchalis placita** (Girard). *Silvery minnow.* Adel; Raccoon River, rare. Mouth much smaller than in previous form; head also narrower.
17. **Pimephales promelas** Rafinesque. *Fat-head.* Beaver Creek, abundant; Raccoon River, Walnut Creek, Des Moines, Lizard Creek, Fort Dodge, and Perry, rare; Four-mile Creek, North River, Adel.
18. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow.* Beaver Creek and Fort Dodge, abundant; Des Moines, Estherville, and Perry, common; Raccoon River and Lizard Creek, rare; Walnut Creek, Adel, Middle River, Four-mile Creek, North River.
19. **Cliola vigilax** (Baird and Girard). *Silver-fin.* Walnut Creek and Des Moines, common; Perry, not common; Raccoon River, Beaver Creek, and Estherville, rare; Middle River, Adel.
20. **Notropis heterodon** (Cope). Estherville, not common.
21. **Notropis cayuga** Meek. Estherville, common; Beaver Creek and Lizard Creek, rare; Adel.
22. **Notropis deliciosus** (Girard). Raccoon River and Beaver Creek, abundant; Walnut Creek and Estherville, common; Des Moines, Lizard Creek, and Perry rare; Fort Dodge, not common; Middle River, Adel, Four-mile Creek.
23. **Notropis topeka** Gilbert. Beaver Creek, Estherville, and Lizard Creek, rare.
24. **Notropis gilberti** Jordan and Meek. Raccoon River and Beaver Creek, abundant; Walnut Creek, Des Moines, Lizard Creek, Fort Dodge, and Perry, common; Middle River, Adel, Four-mile Creek, North River.
25. **Notropis lutrensis** (Baird and Girard).
26. **Notropis whipplei** (Girard). Estherville, Lizard Creek, and Fort Dodge, abundant; Raccoon River, Beaver and Walnut creeks, Des Moines, and Perry, common; Middle River, Adel, North River, Yader River.

27. **Notropis megalops** (Rafinesque). *Shiner.* Beaver and Walnut creeks, Lizard Creek, and Perry, abundant; Des Moines, Raccoon River, Estherville, and Fort Dodge, common; Four-mile Creek, Adel, North River, Middle River.
28. **Notropis ardens** (Cope). *Redfin.* Fort Dodge, not common; Beaver Creek (scales 55), Des Moines, Raccoon River, Perry, Walnut Creek, rare; Adel, Middle River, North River.
29. **Notropis dilectus** (Girard). *Emerald minnow.* Des Moines, Fort Dodge, common; Lizard Creek, not common; Beaver Creek, Estherville, Perry, Walnut Creek, Raccoon River, rare; North River, Adel.
30. **Phenacobius mirabilis** (Girard). Des Moines, common; Raccoon River, Walnut and Beaver creeks, Perry, rare; Middle River, North River, Four-mile Creek.
31. **Rhinichthys atronasus** (Mitchill). *Black-nosed dace.* Lizard Creek, Fort Dodge, Walnut and Beaver creeks, rare.
32. **Hybopsis storerianus** (Kirtland). *Spawn-eater.* Raccoon River, common; Des Moines and Perry, rare; Middle River, Adel, Walnut Creek.
33. **Hybopsis kentuckiensis** (Rafinesque). *Hornyhead.* Estherville, abundant; Walnut and Beaver creeks, Raccoon River, Des Moines, and Fort Dodge, common; Lizard Creek, not common; Perry, rare; Adel, North River.
34. **Semotilus atromaculatus** (Mitchill). *Horned dace.* Raccoon River, common; Beaver and Walnut creeks, Des Moines, Estherville, and Perry, rare; Adel, Lizard Creek, North River.
35. **Notemigonus chrysoleucus** (Mitchill). *Golden shiner; Bream; Roach.* Estherville, common; Des Moines (Raccoon River), Perry, Beaver Creek, rare.
36. **Fundulus zebrinus** Jordan and Gilbert. Fort Dodge, rare.
37. **Zygonectes notatus** (Rafinesque). *Top-minnow.* Raccoon River, rare.
38. **Lucius vermiculatus** (Le Sueur). *Little pickerel.* Beaver Creek, Yader Creek.
39. **Lucius lucius** (Linnæus). *Pike; Northern pickerel.* Fort Dodge, common; Perry, rare; Raccoon River, Adel, Des Moines.
40. **Anguilla chrysypa** Rafinesque. *Common eel.* Raccoon River and Des Moines, rare, occasionally taken with hook and line; Adel.
41. **Labidesthes sicculus** Cope. *Brook silverside.* Adel; Fort Dodge and Raccoon River, rare.
42. **Pomoxis annularis** Rafinesque. *Crappie; Bachelor.* Raccoon River, common in bayou; Middle River.
43. **Ambloplites rupestris** (Rafinesque). *Rock bass; Red-eye; Goggle-eye.* Fort Dodge, abundant; Estherville, common; Raccoon River, not common; Lizard Creek and Perry, rare; Adel.
44. **Lepomis cyanellus** (Rafinesque). *Green sunfish.* Beaver Creek, abundant; Perry, abundant in small bayou; Raccoon River, common in bayou; Des Moines and Fort Dodge, common; Estherville, rare; North River, Middle River, Walnut Creek, Adel.
45. **Lepomis humilis** (Girard). *Red-spotted sunfish.* Raccoon River, abundant in bayou; Perry, abundant; Fort Dodge, common; Middle River, Des Moines, Beaver Creek, Walnut Creek, North River, Adel.
46. **Lepomis pallidus** (Mitchill). *Blue sunfish.* Des Moines, uncommon; Raccoon River, rare; Adel.
47. **Lepomis megalotis** (Rafinesque). *Long-eared sunfish.* Estherville, common; Raccoon River, rare; Beaver Creek.
48. **Micropterus dolomieu** Lacépède. *Small-mouthed black bass.* Fort Dodge, common; Des Moines and Raccoon River, not common; Lizard Creek, Perry, Beaver Creek, and Estherville, rare; Adel, Middle River.
49. **Micropterus salmoides** (Lacépède). *Large-mouthed black bass.* Raccoon River, common in bayou; Perry, rare; Beaver Creek, Adel, Des Moines.
50. **Etheostoma pellucidum clarum** (Jordan and Meek). *Sand darter.* Raccoon River, Fort Dodge, and Perry, rare; Adel.
51. **Etheostoma nigrum** (Rafinesque). *Johnny darter.* Beaver and Walnut creeks, Raccoon River, Des Moines, and Fort Dodge, common; Perry, not common; Lizard Creek, rare; North River, Adel.
52. **Etheostoma caprodes** (Rafinesque). *Log perch.* Estherville, common; Fort Dodge, rare; Des Moines.

53. **Etheostoma aspro** (Cope and Jordan). *Black-sided darter.* Estherville, common; Des Moines, Lizard Creek, Fort Dodge, and Perry, rare; Beaver Creek, North River, Adel.
54. **Etheostoma phoxocephalum** Nelson. Estherville and Perry, rare.
55. **Etheostoma zonale** (Cope). Beaver Creek, Estherville, and Fort Dodge, common.
56. **Etheostoma flabellare** Rafinesque. Fort Dodge, not common; Beaver Creek, Estherville, and Perry, rare; Raccoon River.
57. **Etheostoma jessiæ** (Jordan and Brayton). Beaver Creek.
58. **Etheostoma iowæ** Jordan and Meek. Fort Dodge and Perry, rare.
59. **Perca flavescens** (Mitchill). *Yellow perch.* Estherville and Perry, rare.

III.—THE SKUNK RIVER.

The Skunk River drains a narrow basin between the Iowa and Des Moines rivers. At Ames it is not large, has a sandy bottom, and flows with considerable current. Collections were made in the river and in a small bayou. Squaw Creek is smaller than Skunk River, and in the summer the water is confined to a few holes. In October, 1889, these holes contained many pickerel, bass, suckers, and buffalo-fishes. The following September I collected again in the same holes, but found very few fishes compared with the previous year.

FISHES OF THE SKUNK RIVER.

1. **Ammocœtes branchialis** (Linnæus). *Mud lamprey.* A larval specimen from this river is preserved in the Iowa Agricultural College Museum.
2. **Ictalurus punctatus** (Rafinesque). *Channel cat; White cat; Silver cat.* Skunk River, common.
3. **Ameiurus nebulosus** (Le Sueur). *Common bullhead; Horned pout.* Two specimens in the Iowa Agricultural College Museum have the anal rays 23.
4. **Ameiurus melas** (Rafinesque). *Bullhead.* Skunk River, abundant in the bayou; Squaw Creek, abundant.
5. **Noturus exilis** Nelson. *Stone cat.* Anal rays, 16. A few specimens are preserved in the Iowa Agricultural College Museum.
6. **Noturus gyrinus** (Mitchill). *Stone cat.* Skunk River, rare, anal rays 13 or 14; Squaw Creek, rare.
7. **Ictiobus cyprinella** (Cuv. and Val.). *Red-mouthed buffalo.* Squaw Creek; abundant in 1889, but none taken the following year.
8. **Carpiodes velifer** (Rafinesque). *Quillback; Carp sucker.* Skunk River and Squaw Creek, common.
9. **Catostomus teres** (Mitchill). *Common sucker.* Squaw Creek, abundant; Skunk River, common.
10. **Catostomus nigricans** Le Sueur. *Hog sucker; Stone roller; Hog mullet.* Skunk River, common; Squaw Creek, rare.
11. **Minytrema melanops** (Jordan). *Striped sucker.* Squaw Creek, rare.
12. **Moxostoma duquesnei** (Le Sueur). *Common redhorse; Mullet.* Squaw Creek, abundant; Skunk River, not common.
13. **Moxostoma,** sp. Squaw Creek, rare. Scales, 41; dorsal rays, 15; base of dorsal, 4½ in body; head, 4; depth, 3½; eye, 4½; caudal lobes equal; body very deep; back much arched. These specimens resemble the preceding, but the back is much more arched and the body much deeper.
14. **Moxostoma aureolum** (Le Sueur). Skunk River, rare; head very small
15. **Campostoma anomalum** (Rafinesque). *Stone-lugger; Stone-roller.* Skunk River and Squaw Creek, common.
16. **Chrosomus erythrogaster** Rafinesque. *Red-bellied minnow.* Small brook, near Ames, Iowa, on the University campus; six specimens.
17. **Hybognathus nuchalis** Agassiz. *Silvery minnow.* Squaw Creek, common; Skunk River, rare.

18. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow.* Skunk River, not common; Squaw Creek, abundant.
19. **Pimephales promelas** Rafinesque. *Fat-head.* Skunk River, common in bayou; Squaw Creek, not common.
20. **Cliola vigilax** (Baird and Girard). *Silver-fin.* Skunk River, common.
21. **Notropis heterodon** Cope. Skunk River, not common; found with the following species.
22. **Notropis cayuga** Meek. Skunk River, very abundant in a small bayou; Squaw Creek, common.
23. **Notropis deliciosus** (Girard). Squaw Creek and Skunk River, rare.
24. **Notropis gilberti** Jordan and Meek. Skunk River and Squaw Creek, common.
25. **Notropis whipplei** (Girard). Skunk River and Squaw Creek, common.
26. **Notropis megalops** (Rafinesque). *Shiner.* Squaw Creek and Skunk River, common.
27. **Notropis ardens** (Cope). Skunk River, rare, scales 55; Squaw Creek, rare, scales 44 to 50; lateral line not complete in some specimens; anal rays, 10 to 12.
28. **Notropis dilectus** (Girard). *Emerald minnow.* Skunk River, abundant; Squaw Creek, rare.
29. **Hybopsis kentuckiensis** (Rafinesque). *Hornyhead; River chub; Jerker.* Skunk River and Squaw Creek, common.
30. **Semotilus atromaculatus** (Mitchill). *Horned dace; Creek chub.* College Creek, Ames, common.
31. **Notemigonus chrysoleucus** (Mitchill). *Golden shiner; Bream.* Skunk River, common in the bayou; Squaw Creek, common.
32. **Phenacobius mirabilis** (Girard). Skunk River, not common; Squaw Creek, rare.
33. **Zygonectes notatus** (Rafinesque). *Top-minnow.* Skunk River and Squaw Creek, rare.
34. **Lucius lucius** (Linnæus). *Pike; Northern pickerel.* Several specimens from the Skunk River are contained in the Ames Museum.
35. **Lucius masquinongy** (Mitchill). *Muskellunge.* Skunk River, rare. I have examined the head of a large specimen which weighed 35½ pounds. It was taken from Skunk River, just below the mouth of Squaw Creek. Fishermen report that several were captured at the same place a few years ago.
36. **Labidesthes sicculus** Cope. *Brook silverside.* Skunk River and Squaw Creek, rare.
37. **Pomoxis sparoides** (Lacépède). *Calico bass; Grass bass; Strawberry bass.* Skunk River, not common.
38. **Ambloplites rupestris** (Rafinesque). *Rock bass; Red-eye; Goggle-eye.* Ames, rare. Contained in the Iowa Agricultural College Museum.
39. **Lepomis cyanellus** (Rafinesque). *Green sunfish.* Skunk River, abundant; Squaw Creek, common.
40. **Lepomis humilis** (Girard). *Red-spotted sunfish.* Skunk River, not common.
41. **Lepomis pallidus** (Mitchill). *Blue sunfish.* Squaw Creek, rare.
42. **Micropterus salmoides** (Lacépède). *Large-mouthed black bass.* Skunk River, abundant, mostly young from the bayou; Squaw Creek, common.
43. **Micropterus dolomieu** Lacépède. *Small-mouthed black bass.* Squaw Creek and Skunk River, not common.
44. **Etheostoma nigrum** Rafinesque. *Johnny darter.* Squaw Creek, common; Skunk River, rare.
45. **Etheostoma aspro** (Cope and Jordan). *Black-sided darter.* Skunk River, rare. Lateral line, 70; cheeks and opercles scaly; breast naked; head, 4; depth, 6; anal rays, 11–9. Squaw Creek, scarce.
46. **Etheostoma zonale** (Cope). Skunk River, rare. Scales, 50; dorsal, XI–12; anal rays, 11–7; cheeks, opercles, and breast scaly, the latter naked near isthmus.
47. **Etheostoma jessiæ** (Jordan and Brayton). Squaw Creek, rare. Scales, 48; cheeks scaled; breast naked; dorsal rays, XI or XII–14.
48. **Etheostoma cœruleum** Storer. Skunk River and Squaw Creek, rare.
49. **Etheostoma iowæ** Jordan and Meek. Skunk River, common in the bayou. Sides with 10 or 11 reddish spots, interspersed with darker bands of about the same size. The 2d, 3d, 4th, and 5th extend on sides under pectoral fins. Dorsal with a narrow, dark margin, about half of the fin; below this with a red band below a darker band; soft dorsal, caudal, and pectorals irregularly barred with yellow and darker; anal nearly plain. In some (female) specimens the red spots on the sides were absent, otherwise all were alike in color. Scales, 56; dorsal rays, VIII–IX, 10 or 11; A., 2–7.

IV.—THE IOWA RIVER.

The Iowa River rises in the north-central part of the State. The country near its source is a slightly undulating prairie, becoming more and more broken toward its mouth. The river was visited at Garner, Belmond, Amana, and Iowa City. At Garner the water was confined to a few holes, rather distant from one another, in which grass was so abundant that it was quite impossible to seine. We succeeded, however, in taking a few bullheads (*A. melas*) and the mud minnow (*U. limi*). The great scarcity of water was due to a prolonged season of dry weather, and was an unusual occurrence. The stream at this point was not bordered by timber.

At Belmond the river is from 20 to 40 feet wide. A dam at this place backs the water for some distance above. We collected below the dam, where the bottom was gravelly and sandy. There is much vegetation in the river a short distance below the dam and a weak growth of timber along its banks. The water was clear, the current rather slack, and the river unusually slow. When the mill was in operation there was but little water flowing over the dam. Pickerel seemed quite plentiful in the grass, but only a few were caught in our nets. Small fishes were abundant, especially just below the dam. The temperature on July 29 was 73° F.

At Amana the river is much larger than at Belmond. Aquatic vegetation is very scarce and the bottom sandy. There is not much timber along the banks. A small creek empties into the river at this point, and when we were there the water in the creek was confined to a few holes. From these holes large pickerel were taken, and also many crappies, *P. annularis* and *P. sparoides*. At the mouth of the creek the water was from 4 to 7 feet deep, and the bottom muddy. The examination at Amana was made September 11. The temperature is about the same as in the Cedar River at Waverly.

At Iowa City the river has about the same characteristics as at Amana. It is somewhat larger and deeper, and in some places is bordered by rather low cliffs. There is also more timber along its borders. A small creek with a very muddy bottom near its mouth flows into the river near Iowa City. Collections were made in the river and in the creek by Prof. C. C. Nutting and the writer in October, 1889. I was informed by a fisherman that in former years the larger catfishes, pickerel, buffalo, and bass were very common in the river, and that fishing for the markets in the spring was then quite lucrative. These larger fishes are still taken, but in much less numbers.

Through the kindness of Prof. Nutting I have been able to examine the collection of fishes from the Iowa River in the museum of the Iowa State University, and the additional facts gained thereby have been utilized in the preparation of the following list.

FISHES OF THE IOWA RIVER.

1. **Ammocœtes branchialis** (Linnæus). *Mud lamprey.* A few specimens are contained in the Museum of the Iowa State University.
2. **Petromyson concolor** (Kirtland). *Brook lamprey.* A few specimens in the museum of the Iowa State University.
3. **Amia calva** Linnæus. *Dogfish; Bow-fin; Mudfish.* Iowa City and Amana, not common.
4. **Lepisosteus osseus** (Linnæus). *Common gar-pike; Long-nosed gar; Bill-fish.* Iowa City; said to be quite common in the spring. The specimens examined are in the museum of the Iowa State University.
5. **Polyodon spathula** (Walbaum). *Paddle-fish; Spoon-bill; Duck-billed cat.* The specimens examined are in the museum of the Iowa State University. Said to have been frequently taken in previous years.
6. **Ictalurus punctatus** (Rafinesque). *Channel cat; White cat; Silver cat.* Small specimens were obtained in considerable numbers at Amana and Iowa City. Larger specimens are said to be more rare than formerly.
7. **Ameiurus melas** (Rafinesque). *Bullhead.* Garner and Belmond, common.
8. **Noturus gyrinus** (Mitchill). *Stone cat.* Belmond and Amana, rare. All the specimens taken were small.
9. **Carpiodes velifer** (Rafinesque). *Quillback; Carp sucker.* Iowa City and Amana, very abundant in bayous at the side of the river. The specimens exhibit considerable variations. In some the first dorsal rays are prolonged to near the caudal fin, while in others these rays scarcely reach the middle of the dorsal fin. Some are deeper than others, and in all the profile is quite trenchant.
10. **Catostomus teres** (Mitchill). *Common sucker.* Belmond, Amana, and Iowa City, not common.
11. **Catostomus nigricans** (Le Sueur). *Hog sucker; Stone-roller; Hog mullet.* Belmond, abundant just below the dam.
12. **Moxostoma duquesnei** Le Sueur. *Common redhorse; "Mullet."* Belmond and Iowa City, common; Amana, rare.
13. **Minytrema melanops** (Rafinesque). *Striped sucker.* One specimen was obtained at Amana. This species seems rare in Iowa, and I have taken it in only three localities.
14. **Campostoma anomalum** (Rafinesque). *Stone-lugger; Stone-roller.* Iowa City and Amana, rare; Belmond, common. Scales, 44 to 48.
15. **Chrosomus erythrogaster** Rafinesque. *Red-bellied minnow.* Belmond, abundant.
16. **Hybognathus nuchalis** Agassiz. *Silvery minnow.* Amana, rare.
17. **Hybognathus nubila** (Forbes). Belmond, abundant.
18. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow.* Amana, very common; Iowa City and Belmond, rare.
19. **Cliola vigilax** (Baird and Girard). *Silver-fin.* Iowa City, rare.
20. **Notropis heterodon** (Cope). Rare.
21. **Notropis cayuga** Meek. Belmond, common; the specimens taken at this place agree with those from the Cedar Basin and elsewhere in the State.
22. **Notropis deliciosus** (Girard). Iowa City and Amana, not common.
23. **Notropis topeka** Gilbert. Amana, rare.
24. **Notropis gilberti** Jordan and Meek. Iowa City and Belmond, abundant; Amana, rare.
25. **Notropis whipplei** (Girard). Amana, very common; Iowa City, not common.
26. **Notropis megalops** (Rafinesque). *Shiner.* Belmond and Iowa City, very common; scales before the dorsal fin, small.
27. **Notropis ardens** (Cope). *Redfin.* Belmond, rare. Scales, 43; anal rays, 11; color, dark blue; dark spot at the base of first dorsal ray prominent; base of first dorsal ray midway between the nostril and base of caudal fin.

28. **Notropis dilectus** (Girard). *Emerald minnow.* Amana, very rare. Base of first dorsal ray midway between eye and base of caudal fin; the diameter of the eye equals that of the snout, 3½ in head; about 20 scales before dorsal fin.
29. **Notropis atherinoides** (Rafinesque). *Rosy minnow.* Iowa City, common. The specimens from Iowa City are much larger than the preceding; length, 3½ inches. Color, light olivaceous, with a bright, silvery luster; head, 4½ to 4⅘ in length of body; depth, 5½; diameter of eye greater than the length of the snout, 3 in the head; snout, 3⅘ in head; anal rays, 10; scales in the lateral line, 40; dorsal fin behind ventrals; base of its first ray midway between nostrils or front of orbit and base of caudal fin. These specimens agree very well with *N. atherinoides* from Ohio and Indiana, and are also very similar to the preceding.
30. **Phenacobius mirabilis** (Girard). Amana and Iowa City, rare.
31. **Hybopsis storerianus** (Kirtland). *Spawn-eater.* Amana and Iowa City, common.
32. **Hybopsis kentuckiensis** (Rafinesque). *Hornyhead.* Belmond and Iowa City, common; scales, 43.
33. **Couesius dissimilis** (Girard). Belmond, two specimens, 2½ inches in length. Body elongate, not much compressed; snout pointed; mouth terminal, oblique; maxillary, reaching nearly to front of pupil; diameter of eye equals length of snout, 3½ in head; base of first dorsal ray midway between base of caudal fin and nostril; scales, small before dorsal, about 60 in the lateral line; breast scaly; teeth, 1, 5–5, 1, hooked and without grinding surface. Color, dark olivaceous, a dark lateral band bounded below by the decurved lateral line; a lighter and narrower band above it from upper part of orbit to the caudal fin; fins all dusky. This species seems very rare in Iowa. It was taken among weeds.
34. **Fundulus zebrinus** Jordan and Gilbert. Belmond, rare.
35. **Zygonectes notatus** (Rafinesque). *Top-minnow.* Iowa City, rare.
36. **Umbra limi** (Kirtland). *Mud-minnow; Dogfish.* Garner. A few specimens were taken from one of the isolated holes in the Iowa River.
37. **Lucius lucius** (Linnæus). *Pike; Northern pickerel.* Belmond and Amana, common.
38. **Anguilla chrysypa** (Rafinesque). *Common eel.* One specimen in the Iowa State University Museum was obtained from the Iowa River. The species is very rare in Iowa.
39. **Pomoxis sparoides** (Lacépède). *Calico bass; Grass bass; Strawberry bass.* Amana, common; Iowa City, rare.
40. **Pomoxis annularis** Rafinesque. *Crappie; Bachelor.* Amana; more common than the preceding species.
41. **Chænobryttus gulosus** (Cuv. and Val.). *War-mouth; Red-eyed bream.* Amana, rare.
42. **Lepomis cyanellus** Rafinesque. *Green sunfish.* Belmond, common; Iowa City, not common.
43. **Lepomis pallidus** Mitchill. *Blue sunfish.* Amana and Iowa City, common.
44. **Lepomis megalotis** (Rafinesque). *Long-eared sunfish.* Belmond, common.
45. **Lepomis holbrooki** (Cuv. and Val.). Amana, not common. Opercular flap with a red spot, but without a red margin.
46. **Micropterus salmoides** (Lacépede). *Large-mouthed black bass.* Iowa City, not common; most of the specimens were taken from the creek near its mouth.
47. **Etheostoma nigrum** Rafinesque. *Johnny darter.* Belmond, abundant; Iowa City, common in the creek; Amana, rare.
48. **Etheostoma flabellare** Rafinesque. Belmond and Iowa City, rare; stripes on both sides very prominent.
49. **Etheostoma aspro** (Cope and Jordan). *Black-sided darter.* Belmond and Iowa City, rare.
50. **Etheostoma iowæ** Jordan and Meek. Not common.
51. **Perca flavescens** Mitchill. *Yellow perch.* Belmond, common.
52. **Stizostedion vitreum** (Mitchill). *Wall-eyed pike; Jack salmon.* Iowa State University Museum.

V.—THE CEDAR RIVER AND ITS TRIBUTARIES.

The Cedar River basin properly forms a part of the Iowa River basin, but owing to the fact that above the junction of the two rivers the Cedar River is much the larger stream, it seems best to treat the latter separately.

The Cedar is the second largest river in the State and one of the most picturesque. Together with its northern tributaries it rises in southern Minnesota. Its general course is southeast as far as Moscow, about 15 miles from the Mississippi River, where it turns almost at right angles and, flowing southwest only about 30 miles, empties into the Iowa River. The current of the Cedar River is swifter than that of either the Des Moines or the Iowa. Its bottom for the most part is sandy, especially above Moscow, but there are occasional stretches of mud and some rocky patches.

The Cedar basin is an undulating prairie, with considerable timber along both the main river and its tributaries. There are also many bayous and small ponds which are connected with the river at times of high water. In the larger bayous, where there is much swamp vegetation, pickerel and various species of sunfishes abound. The largest bayou is near Cedar Rapids. On the maps it is usually designated as Cedar Lake, but locally it is known as the "Slough." It is about three-fourths of a mile wide and 2 miles long, and is fast filling up at present. It is connected with the river at all times of the year, contains an abundance of vegetation, and abounds with sunfishes and bullheads. Some black bass and pickerel and many mudfish are also taken from its waters. The Slough is decidedly the fishing-ground for the small boys of Cedar Rapids, and I have often seen them on their homeward trip with strings of bullheads and sunfishes about as long as the average boy himself.

At Austin, Minnesota, the river is little more than a large creek. The bottom is mostly sandy, but there are occasional stretches of deep water with muddy bottom. Aquatic vegetation is scarce and confined to small patches in shallow water. At the time of our visit the volume of water had been much reduced by dry weather. Its temperature on July 25, 1890, was 71° F. Turtle River is a tributary of the Cedar and empties into it near Austin; its current is sluggish and its bottom mostly muddy; it is fed by large marshes and shallow lakes. Rose Creek, another small tributary near Austin, is fed by springs, has a very rocky bottom and a swift current; pickerel seemed especially abundant in it; its temperature on July 25, 1890, was 69° F.

The Cedar River at Waverly is very much larger than at Austin; its banks are bordered with a rather heavy growth of timber; its bottom is very sandy, and its water clear; its temperature on July 31 was 74° F.

The Shellrock River is not much smaller than the Cedar above its junction with the latter, which it much resembles except that its banks are less heavily timbered. Its temperature on July 31 was 74° F. Fishes were about as abundant as in the Cedar River. Near Waverly there are some large springs. We seined in one of the spring branches on the west side of the Cedar River, where the water was less clear than in other similar branches. Fishes were scarce; its temperature was 58° F.

The west branch of the Cedar River is formed by two small creeks near Dumont. The average width of these creeks is less than 30 feet; their bottoms are sandy, with some mud; timber is scarce along their borders. One of them is termed the main fork, the other is called Hartgraves Creek. Near Dumont is a small lake connected

by a small channel with Hartgraves Creek. The bottom of this lake is very muddy and is covered with vegetation. Sunfishes and pickerel were very abundant in it.

At Palo the bottom of the river is sandy, in some places rocky. There are many bayous in this region, and the river is bordered with less timber than at Waverly. Dry creek is a small tributary of the Cedar River near Palo, having a very muddy bottom. We collected on the farm of Mr. Joseph Owens, who informed me that the creek used to be deep and narrow and contained fine pickerel and catfishes. At present it is wider and shallower.

At Cedar Rapids the river is about 700 feet wide. A dam at this place holds the water back over a distance of about 5 miles, thereby increasing the width of the river. This enlarged part contains many islands and much aquatic vegetation. Below the dam, for about one-third of a mile, the current is very swift and the bottom very rocky, but farther down it becomes sandy. There is considerable timber in this region.

Prairie Creek is a western tributary of the Cedar, a small stream bordered in the lower part with timber. Its bottom is usually muddy, with occasional stretches of sand. Mr. Aquilla Miller, who has resided on its banks many years, informed me that the larger fishes were formerly quite abundant in it, but at present only small ones can be found.

Indian Creek is an eastern tributary, smaller than Prairie Creek, with a sandy or rocky bottom, and is bordered by timber. A much greater number of fishes was found in Indian Creek than in Prairie.

At Mount Vernon the bottom of the Cedar River is sandy. Cliffs, called the Palisades, about 60 feet high, occur on the western side. A few small streams flow into the river near this place. At West Liberty the current was more moderate than at the other places visited, but the general characteristics of the river were the same. Most of the collection was obtained from bayous near the river, but a few specimens were taken from a small creek between West Liberty and the river.

FISHES OF THE CEDAR RIVER AND ITS TRIBUTARIES.

1. **Ammocœtes branchialis** (Linnæus). *Mud lamprey.* This small lamprey ascends clear brooks in the spring for the purpose of spawning, and at that time of the year large numbers can be captured. They were spawning at Cedar Rapids April 20, 1889, and about April 10, 1891, the season lasting about two weeks. I have secured many specimens from small brooks near Cedar Rapids, but have seen none from other localities and am not aware of their being taken at other times than in the spring. Specimens seldom exceed 6¼ inches in length. It would be an easy matter to destroy large quantities of these lampreys in the spring, if it were thought expedient, in view of the injury which they are supposed to inflict upon some of the food-fishes. They undoubtedly do some destruction, but how much it is difficult to say. I have compared the lampreys from Cedar Rapids with specimens from Ithaca, New York, and regard the species from both localities as identical.
2. **Petromyzon concolor** (Kirtland). *Brook lamprey.* I have never observed this species in the spring. It is represented in the Coe College Museum by a single specimen, collected in the Cedar River several years ago by Prof. F. Starr.
3. **Polyodon spathula** (Walbaum). *Paddle-fish; Spoon-bill; Duck-billed cat.* Cedar Rapids, rare. The snouts of a few individuals, collected in the Cedar River during the past ten years, are in the Coe College Museum.
4. **Scaphirhynchus platyrhynchus** (Rafinesque). *Shovel-nosed sturgeon.* An occasional specimen is taken from the Cedar River with hook and line.

5. **Lepisosteus osseus** (Linnæus). *Common gar-pike; Long-nosed gar; Bill-fish.* Cedar Rapids, common. A few specimens from this locality are contained in the Coe College Museum. The species also occurs in the river.
6. **Amia calva** Linnæus. *Dogfish; Bow-fin; Mudfish.* Very abundant in the Slough and occasionally taken from the Cedar River.
7. **Ictalurus punctatus** (Rafinesque). *Channel cat; White cat; Silver cat.* Cedar Rapids, common; Palo, Cedar River, several small specimens taken in the seine. During the months of June and July many specimens of this species are taken from the Cedar River with hook and line. The best bait seems to be fibrin from blood. The favorite fishing-places are just below the dam or below Sinclair's packing-house, the latter apparently being the best. The water below the packing-house is far less clear and pure than below the dam.
8. **Ameiurus natalis** (Le Sueur). *Yellow cat.* Indian Creek, scarce. Anal rays, 25; base of anal, $3\frac{1}{6}$ in the length of the body and longer than the length of the head.
9. **Ameiurus nebulosus** (Le Sueur). *Common bullhead; Horned pout.* Dry Creek, Palo, common; Dumont, not common; anal rays, 20 to 23; Indian Creek and Austin, Turtle River, rare.
10. **Ameiurus melas** (Rafinesque). *Bullhead.* Cedar Rapids, abundant in the Slough; Indian Creek, Dumont, and Dry Creek, common; Waverly (Shellrock and Clear rivers), Prairie Creek, and Mount Vernon, not common.
11. **Leptops olivaris** (Rafinesque). *Mud cat; Flat-head cat.* Several large specimens of this species were reported taken from the Cedar River with hook and line in July, 1890, the largest weighing about 20 pounds. I saw only a few of these, but all that I examined were of this species. It is not unlikely that some of the larger specimens recorded may have belonged to *A. nigricans*. According to the anglers, cat fishing was better in July, 1890, than it had been at any time during the past ten years.
12. **Noturus flavus** (Rafinesque). *Stone cat.* Cedar Rapids, rare.
13. **Noturus gyrinus** (Mitchill). *Stone cat.* West Liberty, rare; anal, 15 rays; caudal fin continuous with adipose; dorsal spine not serrated; head, $3\frac{1}{3}$ in length of body; top of head flattish. Waverly (Cedar River), rare; anal, 15; head, $3\frac{2}{3}$; depth, 4; pectoral spine entire, $2\frac{1}{3}$ in head. Dumont, Dry Creek, and Indian Creek, rare.
14. **Carpiodes velifer** (Rafinesque). *Quillback; Carp sucker.* Cedar Rapids, very abundant in still bays along the sides of the river. Most of the specimens taken are small. Different individuals show considerable variation, but I have not been able to detect any constant characters by which to separate them. Prairie Creek, abundant; Dumont, Austin, Indian Creek, and West Liberty, common; Waverly (Shellrock and Cedar rivers), not common.
15. **Catostomus teres** (Mitchill). *Common sucker.* Dry Creek at Palo, Prairie Creek, and Cedar Rapids, abundant; Waverly (Shellrock River), Dumont, Austin, Indian Creek, and West Liberty, common; Cedar River at Palo, rare.
16. **Catostomus nigricans** (Le Sueur). *Hog sucker; Stone-roller; Hog mullet.* Dry Creek, at Palo, abundant; Dumont, common; Austin, and Cedar River at Waverly, not common; Cedar Rapids, Prairie Creek, Indian Creek, and Mount Vernon, rare.
17. **Erimyzon sucetta** (Lacépède). *Chub sucker; Sweet sucker.* West Liberty, two specimens were taken from a bayou near the river. Scales, 38; dorsal rays, 12; anal, 7; depth, $3\frac{2}{5}$; head, 4; longest specimen, $7\frac{1}{2}$ inches. This species seems rare in Iowa, and I have taken no specimens from other localities than the above.
18. **Moxostoma anisurum** (Rafinesque). *White-nosed sucker.* Austin, rare; dorsal, 15 rays; body deeper than in *M. duquesnei*; depth, $3\frac{1}{4}$; dorsal region arched more than in *M. duquesnei;* color, more silvery, and lower lip thinner and with sharper angle. Waverly, Shellrock, rare; depth, $3\frac{1}{4}$; dorsal rays, 15.
19. **Moxostoma duquesnei** (Le Sueur). *Common redhorse; "Mullet."* West Liberty, common; lower fins red; dorsal rays, 14. Cedar Rapids, Prairie Creek, and Palo (Dry Creek), common. Waverly (Shellrock River), common; dorsal rays, 12 to 13; depth, $4\frac{1}{4}$ in the length of the body. Dumont, common; scales, 44; dorsal rays, 13; upper lip with a dark margin; color darker and less silvery than in specimens taken elsewhere. Austin, not common; dorsal rays, 12 to 14; color less silvery than usual; depth scarcely more than length of head.

19½. **Minytrema melanops** Rafinesque. *Striped sucker.* Cedar River, scarce.

20. **Campostoma anomalum** (Rafinesque). *Stone-lugger; Stone-roller.* West Liberty and Prairie creeks, rare. Indian Creek, not common; head, 4¼ in the length of the body; dorsal rays, 7 or 8; anal rays, 7 or 8; snout, 3 in length of the head; first dorsal ray midway between base of caudal and tip of snout. Palo (Dry Creek), Waverly (Cedar and Shellrock rivers), Dumont, common; scales, 47 to 53. Austin, not common.
21. **Chrosomus erythrogaster** Rafinesque. *Red-bellied minnow.* This species is seldom found in Iowa except in spring brooks, and is nowhere abundant. It was common in a small brook at Mount Vernon, and rare at the following localities: Palo, Dry Creek, Waverly, taken in a small spring brook, tributary to the Cedar River; Austin.
22. **Hybognathus nuchalis** Agassiz. *Silvery minnow.* Prairie Creek, common; Indian Creek, Dumont and Waverly (Shellrock River), rare.
23. **Hybognathus nubila** (Forbes). Waverly (Shellrock River) and Austin, not common.
24. **Pimephales promelas** Rafinesque. *Flat-head.* Cedar rapids, very abundant. Nearly all the specimens were taken in a ditch along the Illinois Central Railroad near Cedar Rapids, where no fishes had been found the previous summer. No other species, moreover, were observed in this ditch, which is in communication with the Slough in times of high water. Only two species of *Pimephales* occur in Iowa. *P. promelas* prefers sluggish or stagnant pools with a muddy bottom, while *notatus* always inhabits clear water. This species was also obtained at the following localities: Indian Creek, common; Palo, Dry Creek, not common. West Liberty, Prairie Creek, Waverly (Shellrock River), Dumont, and Austin, rare.
25. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow.* Indian Creek, abundant; West Liberty, Cedar Rapids, Prairie Creek, Palo, Dry Creek, Waverly (Cedar River and Shellrock River), Dumont, and Austin, common; Palo, Cedar River, rare.
26. **Cliola vigilax** (Baird and Girard). *Bullhead minnow.* Palo and Cedar Rapids, common.
27. **Notropis anogenus** Forbes. Austin, Minnesota, rare. This species very much resembles *N. heterodon*, from which it differs in having a smaller and more oblique mouth.
28. **Notropis heterodon** (Cope). West Liberty; dorsal nearer tip of snout than base of caudal; dark lateral band prominent. Found near the shore where there is little current and an abundance of weeds. Cedar Rapids, not common; Dumont, rare; Waverly (Shellrock River).
29. **Notropis cayuga** Meek. Indian Creek, rare. Head, 4 in the length of the body; depth, 4⅓; dorsal (origin of first ray) slightly nearer tip of snout than base of caudal fin; 14 or 15 scales in a series before dorsal fin; lateral line complete; scales, 35 or 36; anal rays, usually 8, seldom 9; snout blunt; mouth small. Color, dark above; outline of scales on upper part of body very distinct; dark lateral band present, passing around snout on upper jaw only. Waverly (Shellrock River), Austin (Minnesota), Dumont, Prairie Creek, and West Liberty, rare. This species is usually found with *Notropis heterodon* Cope, and *Notropis anogenus* Forbes, and is nowhere abundant. These three species are among the most feeble and insignificant of our fresh-water fishes.
30. **Notropis deliciosus** (Girard). Indian Creek, Cedar Rapids, and Dumont, common; Waverly (Shellrock and Cedar rivers), not common; West Liberty, Prairie Creek, and Palo, rare.
31. **Notropis topeka** Gilbert. Waverly (Cedar River) and Shellrock (Waverly), rare. This species resembles *Notropis deliciosus*, but has smaller eyes and a more compressed body.
32. **Notropis gilberti** Jordan and Meek. Palo, abundant; Shellrock River, at Waverly, very common; Waverly (Cedar River) and Dumont, common; Cedar Rapids, not common; Prairie Creek, rare; West Liberty. This species is one of the most abundant in Iowa, and is found in clear, running water.
33. **Notropis whipplei** (Girard). West Liberty and Prairie Creek, abundant; Cedar Rapids, common; head, 4; depth, 4 to 4½; scales, 36 to 38. Waverly, Cedar River, and Dumont, common; Waverly (Shellrock River), rare; lateral line, 35.
34. **Notropis megalops** (Rafinesque). *Common shiner.* West Liberty, Shellrock River at Waverly, Palo, and Dumont, abundant; Waverly (Cedar River), Indian Creek, Prairie Creek, and Cedar Rapids, common. This species is variable. The scales before the dorsal fin are usually small. In most of the specimens from Missouri and Arkansas the scales before the dorsal are large.

35. **Notropis jejunus** (Forbes). Cedar Rapids, rare. Head, 4 in length of the body; depth, 4¼ to 4½; body robust; snout bluntish; mouth a little oblique; dorsal (origin of first ray) nearer tip of snout than base of caudal fin; 14 or 15 scales before the dorsal; scales in the lateral line, 36 or 37; diameter of the eye equal to the length of the snout; 3½ in the length of the head; anal rays, 6 or 7, usually 7; lateral line slightly decurved. As regards form and color this species very much resembles *H. nuchalis* Agassiz.
36. **Notropis ardens** (Cope). *Redfin.* Indian Creek, common; scales, 43 to 49; anal rays, 11 or 12; depth, 3¾ to 4¾; the larger specimens are the deeper; occasionally one is found whose depth is 5. Dumont, not common; scales, 45 to 48; anal rays, 10 or 11. Prairie Creek, Waverly (Shellrock River), and Palo, rare. Austin, rare; scales, 42 to 49. This species is rather rare in Iowa. It is very variable and seems to vary greatly with age. The smaller specimens are light-colored and slender, the larger very dark. The number of scales in the lateral line vary much. The dark at the base of the dorsal fin is always present, but in some specimens it is more distinct than in others.
37. **Notropis dilectus** (Girard). *Emerald minnow.* Waverly (Cedar River); head, 4½; depth, 5½; specimens rather darker than usual. Austin (Minnesota) and Waverly (Shellrock River), common; Indian Creek and West Liberty, rare; Dumont, common. Diameter of eye equals the length of the snout, 3½ in the head. Cedar Rapids, common; head, 4½; depth, 4¾; scales in the lateral line, 38; dorsal midway between the pupil and base of caudal fin; anal rays, 10 or 11.
38. **Notropis atherinoides** Rafinesque. Waverly (Shellrock River), rare; some specimens are very slender. Indian Creek, common; the longest specimens are 3½ inches in length; anal rays, 9 to 11, usually 10; base of first dorsal ray midway between base of caudal fin and eye; 18 to 20 scales before dorsal fin; eye 3½, equal to the snout; mouth large; maxillary reaching past the front of the orbit; snout pointed; lower jaw slightly the longer; scales in lateral line, 40 to 43. Cedar Rapids, common. These specimens agree with the above. The body is usually deeper than in *N. dilectus;* sides with a broad plumbeous band. This species is closely related to the preceding.
39. **Phenacobius mirabilis** (Girard). Indian Creek, West Liberty, Palo, and Cedar Rapids, rare.
40. **Rhinichthys atronasus** (Mitchill). *Black-nosed dace.* Palo and Mount Vernon, rare.
41. **Hybopsis dissimilis** (Kirtland). Cedar Rapids and Waverly (Shellrock River), rare. Waverly (Cedar River), common. Near the shore in shallow water many specimens were taken, but none were obtained from other points in the stream.
42. **Hybopsis storerianus** (Kirtland). Prairie Creek, rare.
43. **Hybopsis kentuckiensis** (Rafinesque). *Hornyhead; River chub; Jerker.* Waverly (Shellrock River) and Palo, common. Indian Creek, West Liberty, Waverly (Cedar River), Dumont, and Cedar Rapids, rare.
44. **Semotilus atromaculatus** (Mitchill). *Horned dace; Creek chub.* Indian Creek, West Liberty, Palo, Dumont, Mount Vernon, and Cedar Rapids, rare.
45. **Leuciscus elongatus ?** (Kirtland). Palo (Dry Creek). Only one specimen, measuring 4½ inches in length was taken. Teeth, 5–5, slightly hooked at the tip, no grinding surface; edges beveled, making a cutting edge. Body elongate, slender; dorsal fin midway between tip of snout and base of caudal fin; mouth terminal, oblique, rather large, but smaller than in *L. elongatus* from Yellow River. Scales on anterior portion of the body smaller than rest of scales. About 35 scales in a series before dorsal fin; lateral line decurved; scales in the lateral line, 54; dorsal fin above ventrals; dorsal rays, 8; anal rays, 8; maxillary reaching to the front of the orbit. Diameter of eye nearly equal to length of snout, 4 in the head; head, 3⅝ in length of body; depth, 4½. Color, plain olivaceous, lighter below; fins with a tinge of yellowish.
46. **Notemigonus chrysoleucus** (Mitchill). *Golden shiner; Bream; Roach.* Indian Creek, rare; anal rays, 13; dorsal, 8; scales in the lateral line, 41. West Liberty, Waverly (Shellrock River), Palo, Dumont, and Cedar Rapids, rare.
47. **Hiodon tergisus** Le Sueur. *Moon-eye; Toothed herring.* Cedar Rapids, rare.
48. **Dorosoma cepedianum** (Le Sueur). *Gizzard shad; Hickory shad; Mud shad.* Palo (Cedar River), one specimen taken from a bayou; Cedar Rapids, rare.

49. Salvelinus fontinalis (Mitchill). *Brook trout.* A few specimens are occasionally caught in McCloud Run, near Cedar Rapids, which is fed by a large spring. In former years a great many fishes were hatched artificially at this place, and the trout now taken were probably introduced at that time.

50. Fundulus zebrinus Jordan and Gilbert. Dumont, rare.

51. Zygonectes notatus (Rafinesque). *Top-minnow.* Indian Creek, rare; anal rays, 11 to 13; scales, 34. Cedar Rapids, rare. This species is always found sparingly, sometimes in clear water, but usually among weeds.

52. Zygonectes dispar Agassiz. West Liberty, common in bayou. Anal rays, 11; dorsal, 7 or 8; scales, 33; head, 3¼; depth, 4, with 10 bars; dark blotch on side of head includes eye in all specimens.

53. Umbra limi (Kirtland). *Mud minnow; Dogfish.* Dumont, rare. This species is found in isolated ponds near the streams.

54. Lucius vermiculatus (Le Sueur). *Little pickerel.* West Liberty, common in bayou; Palo, rare, taken in a small bayou; Cedar Rapids, common in the Slough.

55. Lucius lucius (Linnæus). *Pike; Northern pickerel.* Waverly (Cedar and Shellrock rivers), common; found along the banks of the stream among the weeds and grass; Dumont, abundant, taken from the lake; Cedar Rapids, common in the river and Slough.

56. Anguilla chrysypa (Rafinesque). *Common eel.* This species is occasionally taken by anglers near Cedar Rapids, and during last summer one angler is said to have captured over 40 specimens at that place. Rev. Mr. Parmont informs me that quite a number have been obtained from the Cedar River near Waterloo during the past spring (1891). Many specimens have also been planted in the Cedar River by Mr. Shaw, of Cedar Rapids.

57. Eucalia inconstans (Kirtland). *Brook stickleback.* Waverly, rare, taken from a small spring brook tributary to the Cedar River; Mount Vernon, a few specimens from a small pond.

58. Labidesthes sicculus Cope. *Brook silverside.* West Liberty, Cedar Rapids, and Cedar River at Waverly, common; Shellrock River at Waverly, Mount Vernon, and Indian Creek, rare.

59. Pomoxis sparoides (Lacépède). *Calico bass; Grass bass; Strawberry bass.* West Liberty, Waverly (Shellrock River), Cedar Rapids, and Dumont, common; Palo (bayou), not common; Indian Creek, rare.

60 Pomoxis annularis Rafinesque. *Crappie; Bachelor.* Cedar Rapids, not common; Waverly (Shellrock River), rare. This species is much less abundant than the preceding in the Cedar basin, but in the Des Moines River at Des Moines the opposite is true.

61. Chænobryttus gulosus (Cuv. and Val.). *War-mouth; Red-eyed bream.* West Liberty and Cedar Rapids, common; taken from grassy bayous.

62. Ambloplites rupestris (Rafinesque). *Rock bass; Red-eye; Goggle-eye.* Cedar Rapids and Dumont, common; Waverly (Cedar River) and Shellrock River, rare.

63. Lepomis cyanellus (Rafinesque). *Green sunfish.* Prairie Creek, abundant; West Liberty, Palo, Dumont, and Cedar Rapids, common; Indian Creek and Waverly (Cedar and Shellrock rivers), rare.

64. Lepomis macrochirus Rafinesque. Waverly (Cedar River) and Dumont, rare.

65. Lepomis humilis (Girard). *Red-spotted sunfish.* Cedar Rapids, rare.

66. Lepomis pallidus (Mitchill). *Blue sunfish.* Indian Creek, West Liberty, Waverly (Cedar River), Palo, and Cedar Rapids, common; Waverly (Shellrock River), rare.

67. Lepomis megalotis (Rafinesque). *Long-eared sunfish.* Dumont, rare. "Ear-flap" with pale margin; cheeks with blue stripes; yellow spots on the soft dorsal; scales in lateral line, 35.

68. Lepomis holbrooki (Cuv. and Val.). Cedar Rapids, rare; West Liberty, common. Body deep, much as in *L. megalotis*, but more compressed; mouth small; maxillary reaching to the front of the eye; opercular flap small, its posterior margin red; teeth blunt, almost paved; brownish and bluish stripes on the cheeks; dorsal, 10–11; scales, 40 to 42; head, 3; depth, 2 to 2⅓; sides with brownish or orange spots; unpaired fins spotted; eye, 3⅓ to 3½ in head. This species was quite common in the large bayou near the river.

69. Lepomis gibbosus (Linnæus). *Common sunfish; Pumpkin-seed.* Indian Creek, not common; lateral line, 40. Waverly (Shellrock River), rare. Cedar Rapids, rare in the river, common in the Slough.

70. **Micropterus dolomieu** Lacépède. *Small-mouthed black bass.* Cedar Rapids, Dumont, Indian Creek, and Waverly (Shellrock River), common; Palo, rare. This species usually lives in clear, running water. The next species is more abundant in sloughs or in water with sluggish current.

71. **Micropterus salmoides** (Lacépède). *Large-mouthed black bass.* Palo, Cedar Rapids, Waverly, (Shellrock and Cedar rivers), and West Liberty (slough), common; Indian Creek, rare.

72. **Etheostoma pellucidum clarum** (Jordan and Meek). Cedar River, rare. The specimens agree very well with the description of individuals taken at Ottumwa by Jordan and Meek in 1884.

73. **Etheostoma nigrum** Rafinesque. *Johnny darter.* Indian Creek, West Liberty, Waverly (Shellrock and Cedar rivers), Palo, Dumont, Prairie Creek, and Cedar Rapids, abundant. This is by far the most abundant darter in Iowa.

74. **Etheostoma caprodes** (Rafinesque). *Log perch.* Waverly (Shellrock) and Cedar Rapids, rare. Dorsal, 14 or 15; lateral line with 85 scales.

75. **Etheostoma aspro** (Cope and Jordan). *Black-sided darter.* Indian Creek, not common; some specimens have a very large head and slender body. West Liberty, Waverly (Shellrock and Cedar rivers), and Dumont, rare. Prairie Creek and Cedar Rapids, common.

76. **Etheostoma phoxocephalum** Nelson. Palo and Cedar Rapids, rare.

77. **Etheostoma evides** Jordan and Copeland. Cedar Rapids, rare.

78. **Etheostoma zonale** (Cope). Indian Creek, common. Breast, cheeks, opercles, and nape scaly; dorsal, XI–11; scales, 43. Cedar Rapids, Waverly (Cedar and Shellrock rivers), and Dumont, rare.

79. **Etheostoma flabellare** Rafinesque. Indian Creek, Palo, and Cedar Rapids, not common. The lateral stripes are very distinct on all Iowa specimens.

80. **Etheostoma cœruleum** Storer. Indian Creek, common. Cedar Rapids, not common. Scales, 45; dorsal, IX–X, 12. Waverly (Cedar and Shellrock rivers), not common. A few specimens of *spectabile* form.

81. **Etheostoma jessiæ** Jordan and Brayton. Indian Creek and Cedar Rapids, rare. Scales, 49; cheeks scaly; dorsal, X–12; scales in the lateral line, 49.

82. **Etheostoma iowæ** Jordan and Meek. Indian Creek, common. Color of male, light yellowish or olivaceous, very light below, dark above; upper two-thirds of body specked; sided with twelve dark vertical bars. The first bar is above and behind the opercle, the last one (very faint) at base of caudal fin. Between these dark bars are golden bars, which extend rather irregularly on sides of belly. Cheeks mottled with dark, a dark band extending downward and forward from the eye, and also upward and backward from the eye. Spinous dorsal dark at base and margin; the rest of the fin is red; soft dorsal with about five rows of brownish spots; caudal and pectoral fins also barred, golden at base of the latter; ventrals and anal white. Color of females similar to males, but the dark bars are less conspicuous, the markings more reticulated; no golden bars; all fins except ventrals barred with brown spots. Dorsal fin, cheeks, and opercles scaly; breast naked; scales in the lateral line, 55 to 58; head, 4; D., 5½ to 5¾. Shellrock River, Waverly, and Dumont, rare. This species is common in Iowa, but so far as known its distribution is limited to the State whose name it bears.

83. **Etheostoma microperca** Jordan and Gilbert. *Least darter.* West Liberty, rare. D., VII–9.

84. **Stizostedion vitreum** (Mitchill). *Wall-eyed pike; Jack salmon.* This species is known in Iowa by the name of pike.

85. **Stizostedion canadense** (C. H. Smith). *Sauger; Sand pike.* Both this and the preceding species are occasionally taken in the Cedar River, but I have only observed the former. They are less abundant now than formerly.

86. **Perca flavescens** (Mitchill). *Yellow perch.* Dumont, common in the lake; Cedar Rapids, rare.

87. **Aplodinotus grunniens** Rafinesque. *Fresh-water drum.* This species seems to be quite common near Cedar Rapids in the spring. I have never caught any with the seine, but have seen many specimens that were taken with hook and line below the dam at Cedar Rapids.

VI.—CLEAR LAKE.

Clear Lake is situated near the source of the Cedar and Iowa rivers, its outlet being a tributary of the Shellrock River. Its greatest length is about 5½ miles and its greatest width about 2 miles. Its longest diameter is east and west. The lake is quite shallow, not exceeding 20 feet in depth, while the greater part of it is less than 10 or 12 feet deep. Portions of the lake contain considerable vegetation. At the time of our visit the water was about 4 feet lower than usual, and no water was flowing in or out. The inlets are very small streams and the water in the lake was below the level of their sources. The chief game fishes are both species of the black bass, the wall-eyed pike, perch, and the pickerel. We collected at different points near the shore.

THE FISHES OF CLEAR LAKE.

1. **Notemigonus chrysoleucus** (Mitchill). *Roach; Golden shiner; Bream.* Rare.
2. **Fundulus zebrinus** Jordan and Gilbert. Rare.
3. **Labidesthes sicculus** Cope. *Brook silverside.* Common.
4. **Lucius lucius** (Linnæus). *Pickerel.*
5. **Poxomis sparoides** (Lacépède). *Calico bass; Grass bass; Strawberry bass.* Not abundant; said to be taken frequently by anglers.
6. **Ambloplites rupestris** (Rafinesque). *Rock bass; Red-eye; Goggle-eye.* About as common as the preceding.
7. **Lepomis pallidus** (Mitchill). *Blue sunfish.* Not common.
8. **Ameiurus melas** (Rafinesque). *Bullhead.* Not abundant.
9. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow.* Abundant.
10. **Notropis hudsonius** (De Witt Clinton). *Spawn-eater.* Abundant. Snout blunt; mouth moderate and slightly oblique; back arched; dorsal over ventrals and nearer snout than base of caudal; eye large, its diameter three in the head and nearly twice the length of the snout; 15 to 17 scales before dorsal fin; head, 4¼ in length of body; depth, 4 to 4½; scales, 38 to 40; teeth, 2, 4–4, 2, or 2, 4–4, 1, hooked at tips with grinding surface. This species is found in large numbers in Clear Lake, Spirit Lake, and the Okobojis, and is the minnow used as bait by the anglers. I have taken it in the Big Sioux River at Sioux City, but not elsewhere than in the localities above mentioned.
11. **Micropterus dolomieu** Lacépède. *Small-mouthed black bass.* This species and the next are frequently taken by anglers. We caught many young specimens in our small nets.
12. **Micropterus salmoides** (Lacépède). *Big-mouthed black bass.* About as abundant as the preceding. Specimens taken by us were small and came from the shallow and warmer water.
13. **Etheostoma nigrum** Rafinesque. *Johnny darter.* Abundant.
14. **Etheostoma flabellare** Rafinesque. Rare.
15. **Perca flavescens** (Mitchill). *Yellow perch.* Abundant.
16. **Stizostedion vitreum** (Mitchill). *"Pike."* Said to be common. A few were caught by a fisherman the day of our visit.

VII.—THE WAPSIPINICON RIVER.

The Wapsipinicon is the next river of importance north and east of the Cedar River and has the same general trend. It also closely resembles the Cedar River in physical characteristics, but is only one-half to two-thirds as large. At Independence the current is about as strong as in the Cedar River at Cedar Rapids. The bottom is rocky just below the dam, but farther down becomes sandy. Our collections were made on sandy bottom. At Anamosa the river is larger and deeper, the current more moderate, and the bottom is sandy and muddy. At the time of our visit the water was too high to permit of seining in the main river, and our collections at this point were obtained in a tributary called Buffalo River. The latter is a moderately large creek, about 30 to 50 feet wide, with sandy and muddy bottom, the depth seldom exceeding 4 feet. The smaller fishes (minnows) were very abundant. Minnow Creek is a small brook, flowing into Buffalo Creek; it has a rocky and sandy bottom, with much grass; only a few fishes were found in it and they were combined with those obtained from Buffalo River. Not far from Buffalo River there is a small bayou which is connected with it at times of high water; in this bayou young sunfishes (*L. pallidus*) were very abundant. At Wheatland the bottom of the river is very sandy, and in a few places near where it was visited it was shallow enough to permit of fording. Several bayous near the river were also examined.

FISHES OF THE WAPSIPINICON RIVER.

1. **Lepisosteus osseus** (Linnæus). *Common gar-pike; Long-nosed gar; Bill-fish.* Wheatland, common in bayous. A few specimens were also taken in the river.
2. **Ictalurus punctatus** (Rafinesque). *Channel cat; White cat; Silver cat.* Wheatland, common in the river. All the specimens were small.
3. **Ameiurus nebulosus** (Le Sueur). *Common catfish.* Independence, common in bayous. Anal rays, 22.
4. **Ameiurus melas** (Rafinesque). *Bullhead.* Wheatland, very abundant in bayous; Independence, abundant in bayous; Anamosa, common.
5. **Ictiobus cyprinella** (Cuv. and Val.). *Red-mouthed buffalo.* Wheatland, common in bayous.
6. **Carpiodes velifer** (Rafinesque). *Quillback; Carp sucker.* Wheatland, abundant in bayous and common in the river. Independence, common; dorsal rays, 23 to 27. Anamosa, common; scales, 36; the specimens taken were all small.
7. **Catostomus teres** (Mitchill). *Common sucker.* Wheatland, a few specimens from bayous and creek. Anamosa, abundant. Scales, 63 to 65.
8. **Catostomus nigricans** Le Sueur. *Hog sucker; Stone-roller; Hog mullet.* Independence, common; Anamosa, not common. Scales, 54.
9. **Moxostoma duquesnei** (Le Sueur). *Common redhorse; Mullet.* Wheatland, Independence, and Anamosa, not common. At Independence, dorsal rays, 14; scales, 40 to 43. At Anamosa, scales, 54.
10. **Hybognathus nuchalis** Agassiz. *Silvery minnow.* Wheatland, abundant; Independence, rare.
11. **Hybognathus nubila** (Forbes). Anamosa, common. Scales, 36 to 38; eye, 3 in head; about 13 scales before dorsal fin.
12. **Pimephales promelas** Rafinesque. *Fat-head.* Wheatland, rare; Independence, rare, taken only in the slough.
13. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow.* Anamosa, abundant; Wheatland, not common; Independence, rare.

14. **Cliola vigilax** (Baird and Girard). *Silver-fin.* Wheatland, rare.
15. **Notropis cayuga** Meek. Wheatland, rare.
16. **Notropis deliciosus** (Girard). Independence, common; 15 to 17 scales before dorsal fin. Anamosa, abundant.
17. **Notropis gilberti** Jordan and Meek. Wheatland, common; Independence, rare; Anamosa, abundant.
18. **Notropis whipplei** (Girard). Wheatland, common; Independence, abundant; scales, 37 to 40; depth, 3¼ to 4⅛ in length. Anamosa, abundant; scales, 38 to 40.
19. **Notropis megalops** (Rafinesque). *Shiner.* Anamosa, abundant; scales, 40 to 45; scales before dorsal, small.
20. **Notropis ardens** (Cope). *Redfin.* Wheatland and Anamosa, not common.
21. **Notropis dilectus** (Girard). *Emerald minnow.* Wheatland, abundant; Independence and Anamosa, rare.
22. **Hybopsis dissimilis** (Kirtland). Independence, rare; scales, 43 to 45; body with irregular dark markings.
23. **Hybopsis storerianus** (Kirtland). Wheatland, common; found only in the river current.
24. **Hybopsis kentuckiensis** (Rafinesque). *Hornyhead.* Anamosa, common; scales, 45.
25. **Notemigonus chrysoleucus** (Mitchill). *Golden shiner; Bream; Roach.* Wheatland, common in bayous; anal rays, 12 to 13. Independence, abundant in a small bayou; anal rays, 12 to 14; scales, 47 to 51; largest specimens, 3½ inches in length. Anamosa, common; anal rays, 11 to 14; scales, 50.
26. **Dorosoma cepedianum** (Le Sueur). *Gizzard shad; Hickory shad; Mud shad.* Wheatland (bayous), rare.
27. **Zygonectes notatus** (Rafinesque). *Top-minnow.* Wheatland (bayous), rare.
28. **Lucius lucius** (Linnæus). *Pike; Northern pickerel.* Independence, common.
29. **Labidesthes sicculus** Cope. *Brook silverside.* Wheatland, not common.
30. **Pomoxis sparoides** (Lacépède). *Calico bass; Grass bass; Strawberry bass.* Wheatland, not common; Independence, common; Anamosa, rare.
31. **Pomoxis annularis** (Rafinesque). *Crappie; Bachelor.* Wheatland, common in bayous.
32. **Ambloplites rupestris** (Rafinesque). *Rock bass; Red-eye; Goggle-eye.* Wheatland, rare.
33. **Lepomis cyanellus** (Rafinesque). *Green sunfish.* Wheatland, abundant in bayous. Independence, common; anal rays and dorsal fins margined with yellow. Anamosa, abundant in a bayou.
34. **Lepomis pallidus** (Mitchill). *Blue sunfish.* Wheatland, common in bayous; Independence and Anamosa, abundant. The young were very abundant in a slough at last-mentioned place.
35. **Lepomis gibbosus** (Linnæus). *Common sunfish; Pumpkin-seed.* Wheatland, common in bayous. Ear flap with a red blotch; cheeks with wavy blue lines; scales, 38 to 40; dorsal rays, X-10.
36. **Micropterus dolomieu** Lacépède. *Small-mouthed black bass.* Wheatland, common; Independence and Anamosa, rare.
37. **Micropterus salmoides** (Lacépède). *Large-mouthed black bass.* Wheatland, less common than the above; Independence, not common; Anamosa, rare.
38. **Etheostoma pellucidum clarum** Jordan and Meek. Wheatland, rare; Independence, one specimen.
39. **Etheostoma nigrum** Rafinesque. *Johnny darter.* Wheatland and Independence, not common. Anamosa, abundant; dorsal, VII or IX-12 to 14, usually IX-13; scales, 48 to 50.
40. **Etheostoma aspro** (Cope and Jordan). *Black-sided darter.* Anamosa, rare.
41. **Etheostoma cœruleum** Storer. Anamosa, common in Minnow Creek.
42. **Etheostoma flabellare** Rafinesque. Anamosa, common; stripes conspicuous.

VIII.—THE MAQUOKETA RIVER.

The Maquoketa River lies north and east of the Wapsipinicon. It is somewhat smaller than the latter, but has about the same physical characteristics. We visited the North Fork near Worthington and the South Fork near Manchester and Hopkinton. The bottom in both was sandy, with very little mud.

Spring Branch, near Manchester, is a small spring brook, the temperature of which is said not to exceed 60° F. Many brook trout are caught in it every year.

Spring Creek at Delhi is a small brook of no special importance. It becomes nearly dry in summer and has a very muddy bottom.

FISHES OF THE MAQUOKETA RIVER.

1. **Ameiurus melas** (Rafinesque). *Bullhead.* Worthington and Manchester, not common.
2. **Catostomus teres** (Mitchill). *Common sucker.* Hopkinton and Worthington, rare; Delhi and Manchester, common.
3. **Catostomus nigricans** Le Sueur. *Hog sucker; Stone-roller; Hog mullet.* Hopkinton, not common; Manchester, common.
4. **Moxostoma duquesnei** (Le Sueur). *Common redhorse; "Mullet."* Hopkinton, not common; Worthington, common; Manchester, abundant.
5. **Campostoma anomalum** (Rafinesque). *Stone-lugger; Stone-roller.* Hopkinton, rare; scales, 50. Delhi and Worthington, not common; Manchester, rare.
6. **Chrosomus erythrogaster** Rafinesque. *Red-bellied minnow.* Worthington, rare; Delhi, very common; Manchester (Spring Branch), common.
7. **Hybognathus nuchalis** Agassiz. *Silvery minnow.* Delhi, common.
8. **Pimephales promelas** Rafinesque. *Fat-head.* Hopkinton, abundant; Worthington, common; Delhi, not common; Manchester, common in small bayou near Spring Branch.
9. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow.* Hopkinton and Worthington, rare; Delhi, not common; Manchester, rare.
10. **Notropis heterodon** (Cope). Manchester, rare.
11. **Notropis cayuga** Meek. Hopkinton, rare.
12. **Notropis deliciosus** (Girard). Worthington, abundant; eye large, 3 to 3¼ in head; snout very short and blunt. Manchester and Hopkinton, rare.
13. **Notropis gilberti** Jordan and Meek. Hopkinton, abundant; Worthington, not common; Delhi and Manchester, common.
14. **Notropis whipplei** (Girard). Hopkinton, rare; Manchester, common.
15. **Notropis megalops** (Rafinesque). *Common shiner.* Hopkinton, not common; Worthington, common; scales before dorsal small. Delhi and Manchester, common.
16. **Notropis ardens** (Cope). *Redfin.* Hopkinton, not common; dorsal fin tipped with red, all other fins red, red on opercle region; body bluish, tinted with red. Worthington, rare. Delhi, rare; length, 2¼ inches; scales, from 45 to 54; about 30 scales before the dorsal; anal rays, 11; dorsal, 8; head, 4¼; depth, 4 to 4¼. This species seems exceedingly variable and is nowhere abundant. Manchester, rare.
17. **Notropis dilectus** (Girard). *Emerald minnow.* Hopkinton, common; Worthington, abundant; 18 to 22 scales before dorsal. In some specimens, the scales nearest the nape are smaller than those on other parts of the body. Scales, 40; anal rays, 10–11, usually 10, sometimes 9; plumbeous band very distinct; head, 4 to 4¼; depth, 5¼; eye, 3⅓. There are probably included under this name more than one species from Iowa. A careful study of more specimens than I have at present is needed to determine this fact.

18. **Rhinichthys atronasus** (Mitchill). *Black-nosed dace.* Worthington, rare; Delhi, common in Spring Branch; no distinct, dusky bands on sides; scales, 60 to 63.
19. **Hybopsis kentuckiensis** (Rafinesque). *Hornyhead; River chub; Jerker.* Worthington, rare; Manchester, common.
20. **Semotilus atromaculatus** (Mitchill). *Horned dace; Creek chub.* Hopkinton and Worthington, rare; Delhi, common; Manchester, more abundant in Spring Branch than in the river; scales, 63.
21. **Notemigonus chrysoleucus** (Mitchill). *Golden shiner; Bream; Roach.* Hopkinton, common: taken in a large bayou. Manchester, rare.
22. **Eucalia inconstans** (Kirtland). *Brook stickleback.* Hopkinton, rare; Worthington, common; dorsal spines usually 5, occasionally 4 or 6. Delhi common; dorsal spines 4 or 6, usually 5. Manchester, rare; taken in a small bayou near Spring Branch.
23. **Lepomis cyanellus** (Rafinesque). *Green sunfish.* Hopkinton, abundant; Worthington, common; Delhi, rare; Manchester, common in small bayou near Spring Branch.
24. **Lepomis pallidus** (Mitchill). *Blue sunfish.* Worthington, rare.
25. **Lepomis megalotis** (Rafinesque). *Long-eared sunfish.* Hopkinton, rare.
26. **Micropterus dolomieu** Lacépède. *Small-mouthed black bass.* Manchester, rare; said to be abundant in the lake above the dam.
27. **Etheostoma nigrum** Rafinesque. *Johnny darter.* Hopkinton, rare; Worthington, not common; Delhi, abundant; Manchester, common.
28. **Etheostoma aspro** (Cope and Jordan). *Black-sided darter.* Hopkinton and Manchester, rare.
29. **Etheostoma zonale** (Cope). Manchester, rare; scales, 50.
30. **Etheostoma flabellare** Rafinesque. Worthington, not common; Delhi, common; stripes on sides conspicuous.
31. **Etheostoma microperca** (Jordan and Gilbert). *Least darter.* Delhi, common; Manchester, rare.

IX.—THE TURKEY RIVER.

The Turkey River at Elkport flows through a much broken country. Its current is strong and its bottom sandy or rocky, with very little mud. In this region the river is bordered in many places by cliffs. Its temperature was 74° F.

Bear Creek is a spring brook, which has a temperature of 65° F. It also flows through a very broken region. In several large springs near the creek the temperature was 50° F. Some trout were planted in the creek a few years ago, but they have not been seen since.

At Fort Atkinson the Turkey River has a sandy bottom and flows through a much less heavily timbered and uneven country than at Elkport.

The Volga River is a large tributary of the Turkey, which at Fayette has a sandy bottom with a few rocks and little mud. Its temperature was 70° F.

FISHES OF THE TURKEY RIVER.

1. **Ameiurus melas** (Rafinesque). *Bullhead.* Fort Atkinson, rare.
2. **Ictiobus** sp. Elkport, common; scales, 43; dorsal rays, 26; color, silvery.
3. **Catostomus teres** (Mitchill). *Common sucker.* Elkport, rare; Bear Creek and Fort Atkinson, common.
4. **Catostomus nigricans** Le Sueur. *Hog sucker; Stone-roller; Hog mullet.* Elkport, not common; Bear Creek, Fort Atkinson, and Fayette, common.
5. **Moxostoma duquesnei** (Le Sueur). *Common redhorse; "Mullet."* Elkport, rare; very slender; depth, 5; head, 4¼; scales, 48; dorsal rays, 14; eye, 4 in head; caudal fin with faint dark margin; color light silvery below, bluish silvery above. Fort Atkinson, not common. Fayette, common; dorsal rays, 12; scales, 43.
6. **Campostoma anomalum** (Rafinesque). *Stone-lugger; Stone-roller.* Elkport, not common; Bear Creek, Fort Atkinson, and Fayette, common.
7. **Chrosomus erythrogaster** Rafinesque. *Red-bellied minnow.* Bear Creek, abundant.
8. **Hybognathus nubila** (Forbes). Fayette, not common.
9. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow.* Elkport, Fort Atkinson, and Fayette, common; Bear Creek, rare.
10. **Pimephales promelas** Rafinesque. *Fat-head.* Fort Atkinson, not common.
11. **Notropis heterodon** (Cope). Bear Creek and Fayette, rare.
12. **Notropis deliciosus** (Girard). Elkport and Fayette, common; Fort Atkinson, rare.
13. **Notropis gilberti** Jordan and Meek. Elkport and Fort Atkinson, common; Fayette, rare.
14. **Notropis whipplei** (Girard). Elkport, not common.
15. **Notropis megalops** (Rafinesque). *Common shiner.* Elkport, common. Bear Creek, common; scales before dorsal fin small. Fort Atkinson and Fayette, abundant.
16. **Notropis jejunus** (Forbes). Elkport, common; form and appearance of *H. nuchalis;* side with prominent plumbeous lateral band; no caudal spot; head, 4; depth, 4⅜ to 5; snout bluntish; mouth oblique; diameter of eye equal to length of snout, 3½ in the length of the head; origin of first dorsal ray slightly nearer tip of snout than base of caudal; scales in lateral line, 38; anal rays, 7. Fayette, rare.
17. **Notropis ardens** (Cope). *Redfin.* Elkport, rare; Fort Atkinson, common; anal rays, 11 or 12; scales, 50.
18. **Notropis dilectus** (Girard). *Emerald minnow.* Elkport, abundant; Fort Atkinson, common.
19. **Rhinichthys atronasus** (Mitchill). *Black-nosed dace.* Bear Creek, abundant.
20. **Hybopsis dissimilis** (Kirtland). Elkport, rare.
21. **Hybopsis storerianus** (Kirtland). Elkport, rare.
22. **Hybopsis kentuckiensis** (Rafinesque). *Hornyhead; River chub; Jerker.* Elkport, common.
23. **Semotilus atromaculatus** (Mitchill). *Horned dace; Creek chub.* Bear Creek, abundant; Fort Atkinson, rare; Fayette, common.
24. **Eucalia inconstans** (Kirtland). *Brook stickleback.* Fort Atkinson, rare; dorsal spines, 5.
25. **Lepomis cyanellus** (Rafinesque). *Green sunfish.* Fort Atkinson, common; Fayette, rare.
26. **Micropterus dolomieu** Lacépède. *Small-mouthed black bass.* Fort Atkinson, common; Fayette, scarce; said to be more frequently taken since the dam was washed out.
27. **Etheostoma nigrum** Rafinesque. *Johnny darter.* Elkport, Bear Creek, and Fayette, rare; Fort Atkinson, common.
28. **Etheostoma aspro** (Cope and Jordan). *Black-sided darter.* Fort Atkinson, rare.
29. **Etheostoma zonale** (Cope). Elkport, rare; Fort Atkinson, common.
30. **Etheostoma flabellare** Rafinesque. Bear Creek, common; Fayette, rare.
31. **Cottus bairdi** (Girard). *Blob; Miller's thumb.* Bear Creek, common; dorsal, VII-16 to VIII-17.

X.—THE YELLOW RIVER.

Yellow River is a small stream in northeastern Iowa, whose source is only about 35 miles west of its mouth. It drains a comparatively small area, but flows through a very broken and picturesque portion of the State. The river is usually bordered on one side or the other with high cliffs of limestone and sandstone. The current is swift and the bottom sandy, gravelly, or rocky. We visited the river northeast of Postville, at which place it is from 20 to 40 feet wide and, except in an occasional hole, does not exceed 4 feet in depth. The temperature was 70° F. Fishes are very abundant in Yellow River, although the number of species observed was small.

Hickory Creek is a small southern tributary of the Yellow River, rising on the upland (prairie) near Postville. In the lower part of its course it is fed by many springs, some of which are quite large. The creek never goes dry except on the upland. The bottom is muddy in the upper part and very rocky in the lower. Its temperature was 56° F.; the temperature of a large spring near by was 48° F. The creek did not contain many fishes, as every rain caused it to become very muddy. Were it not for this fact it could be made an excellent trout stream.

FISHES OF YELLOW RIVER.

1. **Catostomus teres** (Mitchill). *Common sucker.* Yellow River, common.
2. **Catostomus nigricans** Le Sueur. *Hog sucker; Stone-roller; Hog mullet.* Yellow River, common; Hickory Creek, rare.
3. **Campostoma anomalum** (Rafinesque). *Stone-lugger; Stone-roller.* Yellow River and Hickory Creek, common.
4. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow.* Yellow River, common.
5. **Pimephales promelas** Rafinesque. *Fat-head.* Yellow River. Many specimens were taken from a small bayou, but none from the stream.
6. **Chrosomus erythrogaster** Rafinesque. *Red-bellied minnow.* Yellow River, common; Hickory Creek, abundant.
7. **Notropis megalops** (Rafinesque). *Common shiner.* Yellow River, more abundant than any other species.
8. **Notropis dilectus** (Girard). *Emerald minnow.* Yellow River, not common; anal rays, 10; eye small; about 20 scales before the dorsal fin.
9. **Hybopsis kentuckiensis** (Rafinesque). *Hornyhead; River chub; Jerker.* Yellow River, common.
10. **Rhinichthys atronasus** (Mitchill). *Black-nosed dace.* Hickory Creek, rare. Scales, 60 to 64; blackish and somewhat mottled above the lateral line, pale below.
11. **Leuciscus elongatus** (Kirtland). *Red-sided shiner.* Yellow River, rare. Longest specimen, 3¼ inches; head, 3¼ in length of body; lower jaw the longer; scales small, 65 to 70 in the lateral line; anal rays, 8 or 9. The specimens taken were all males, crimson on the sides.
12. **Semotilus atromaculatus** (Mitchill). *Horned dace.* Hickory and Yellow Creek, not common.
13. **Eucalia inconstans** (Kirtland). *Brook stickleback.* Hickory Creek, common; some specimens are black.
14. **Etheostoma nigrum** Rafinesque. *Johnny darter.* Yellow river, common.
15. **Etheostoma flabellare** Rafinesque. Yellow River, common.
16. **Etheostoma cœruleum** Storer. Yellow River, rare.
17. **Cottus bairdi** Girard. *Blob; Miller's thumb.* Hickory Creek, common.

XI.—THE UPPER IOWA RIVER.

The Upper Iowa is a small river which rises in the northeastern part of Iowa, the distance from its source to its mouth being not more than 80 miles. In the upper half of its course it is a typical prairie stream, but farther down it passes through a much broken and timbered country and resembles somewhat a mountain stream. At Chester it is little more than a small creek, with a sandy and muddy bottom. There is a dam across the river at this place, above which the river widens out to form a shallow lake having a muddy bottom. There is considerable vegetation in the lake, which seems to be fairly stocked with pickerel, black bass, and various species of sunfishes. We were told that angling had greatly improved since the building of the dam. We collected both above and below the dam. The temperature was 70° F.

At Decorah, the country is very broken, the river is more than twice as large as at Chester, and there is an abundance of timber along its banks; the current is strong and the bottom rocky or sandy. There are some caves near Decorah in which blind fishes are said to occur. I was unable, however, at the time of my visit, to explore any of them. Across the river from Decorah there is a high bluff or cliff, in which a fracture, parallel with the face of the cliff, has formed a cave, known as the Ice Cave. Ice is produced in this cave during the warm days of summer, but not at other times of the year. Its formation is due, no doubt, to evaporation from the cliff. I visited the cave in June, 1889, with Mr. Joseph White. The temperature of the air outside was 90° F.; in the cave, about 100 feet from the entrance, it was 32° F. Considerable ice was observed. Tradition says that the old Winnishiek chief utilized the cave to preserve meats and other food.

The upper Iowa River was formerly a trout stream, but of late years, so far as I can learn, no trout have been taken from it. The collections at Chester were made on July 24, 1890, and at Decorah, in June, 1889. The species enumerated below are from both places, unless otherwise stated.

FISHES OF THE UPPER IOWA RIVER.

1. **Ameiurus melas** (Rafinesque). *Bullhead.* Decorah, rare.
2. **Catostomus teres** (Mitchill). *Common sucker.* Not common.
3. **Moxostoma duquesnei** (Le Sueur). *Common redhorse.* Chester, not common. Dorsal rays, 14; scales, 45; color darker and less silvery than usual.
4. **Campostoma anomalum** (Rafinesque). *Stone-lugger; Stone-roller.* Not common.
5. **Pimephales promelas** Rafinesque. *Fat-head.* Common.
6. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow.* Common.
7. **Cliola vigilax** (Baird and Girard). *Silver-fin.* Rare.
8. **Notropis deliciosus** (Girard). Decorah, rare.
9. **Notropis whipplei** (Girard). Decorah, rare.
10. **Notropis megalops** (Rafinesque). *Common shiner.* Common.
11. **Notropis ardens** (Cope). *Redfin.* Common.
12. **Notropis dilectus** (Girard). *Emerald minnow.* Common.
13. **Hybopsis kentuckiensis** (Rafinesque). *Hornyhead; River chub; Jerker.* Rare.
14. **Rhinichthys cataractæ** (Cuv. and Val.). *Long-nosed dace.* Decorah, rare.
15. **Rhinichthys atronasus** (Mitchill). *Black-nosed dace.* Rare.
16. **Eucalia inconstans** (Kirtland). *Brook stickleback.* Chester, rare.
17. **Lepomis megalotis** (Rafinesque). *Long-eared sunfish.* Chester, rare.
18. **Etheostoma nigrum** Rafinesque. *Johnny darter.* Decorah, common.

DRAINAGE OF THE MISSOURI RIVER.

I.—THE MISSOURI RIVER.

The Missouri River at Sioux City is wide and shallow, with a rapid current, the bottom being composed of shifting quicksand. There are also many islands at this point, some composed of hard and others of soft materials. The water has a whitish or creamy tint, due to the fine silt held in suspension. The fishes when taken from the river have a pale or sickly appearance, but if placed for a time in clear water they assume their normal colors. The seining was done close by some islands, near the mouth of the Big Sioux River.

FISHES OF THE MISSOURI RIVER.

1. **Polyodon spathula** (Walbaum). *Paddle-fish; Spoon-bill; Duck-billed cat.* One specimen of this species is preserved in the agricultural college at Ames, Iowa. It was taken from the Missouri River in Harrison County, by E. G. Taylor, of Logan, Iowa. Specimens are occasionally caught near Sioux City,
2. **Scaphirhynchus platyrhinchus** (Rafinesque). *Shovel-nosed sturgeon.* Common.
3. **Ictalurus punctatus** (Rafinesque). *Channel cat; White cat; Silver cat.* Common.
4. **Nocturus flavus** (Rafinesque). *Stone cat.* Common. Anal rays, 15; head, 4; depth, 6½; width of head, 4½.
5. **Carpiodes velifer** (Rafinesque). *Quillback; Carp sucker.* Rare.
6. **Hybognathus nuchalis** Agassiz. *Silvery minnow.*
7. **Notropis dilectus** (Girard). *Emerald minnow.* Rare. The specimens secured in this locality were small and differed somewhat from those obtained elsewhere in the State. The first dorsal ray is midway between the nostril and the base of the caudal. Diameter of eye very large, 3 in the head; snout short, two-thirds diameter of the eye; body more compressed than usual in this species; scales 37, about 28 scales before the dorsal; head, 4½; depth, 4½; color, bright olivaceous with faint plumbeous band overlaid with silvery. This species very much resembles *N. atherinoides caddoensis* Meek, of the Ozark region, but the specimens at hand are too small for positive comparison.
8. **Hybopsis gelidus** (Girard). Abundant; the longest specimens measure 3 inches in length. Body elongate, robust, not much compressed; dorsal region in front of dorsal fin compressed to an edge; profile curved (convex) from snout to dorsal fin; snout bluntish, overhanging the large horizontal mouth; barbels at posterior end of maxillary, long; eye small, high up, its diameter 5 in head; caudal peduncle slender. Caudal fin deeply forked, the middle rays less than half the length of the longest rays, the lower lobe dusky. Dorsal fin with first ray rudimentary and less than half the height of the fin; the second ray produced into a filament, which is from one-third to one-fourth as long as the entire ray. Dorsal rays, 8; anal rays, 8. Head, 4½ in length; depth, 5½ to 5½; scales 45, about 18 scales before the dorsal fin. The scales are smaller in this region than on the rest of the body. Teeth, 1, 4–4, 1, hooked and crenate. Lateral line complete; color, light olivaceous with a very faint plumbeous band on sides, overlaid by silvery, silvery luster very faint.
9. **Platygobio gracilis** (Richardson). *Flat-headed chub.* Common; length, 3¾ inches; scales, 50 to 54; teeth, 2, 4–4, 2, without grinding surface, hooked at the tips, the first tooth rather more slender than the others; eye, 4 in the head; head, 4½; depth, 5½; barbel well developed; color, light olivaceous, silvery, no markings at all.
10. **Dorosoma cepedianum** (Le Sueur). *Gizzard shad; Hickory shad; Mud shad.* Rare.
11. **Hiodon alosoides** (Rafinesque). *Moon-eye; Toothed herring.* Rare.

II. THE BIG SIOUX RIVER.

The Big Sioux River, at Sioux Falls, South Dakota, has a very rocky bed above the falls, while below the falls the bottom is both muddy and rocky. At Sioux City the river is much larger and has a very muddy bottom. A short distance above its mouth it widens into a sort of lake. There is some timber along the shores and considerable vegetation in the lake. Our collections were made below the falls, at Sioux Falls, in July, 1880, and near the mouth of the river, in the neighborhood of Sioux City, in August, 1880.

FISHES OF THE BIG SIOUX RIVER.

1 Ictalurus punctatus (Rafinesque) *Channel cat, White cat; Silver cat.* Sioux City, common.

2 Noturus flavus (Rafinesque) *Stone cat.* Sioux Falls, one specimen. Dorsal rays, 14; pectoral spine with retrorse serræ in front, grooved behind; head, 3½; depth, 6. Sioux City, rare.

3 Noturus gyrinus (Mitchill). *Stone cat.* One specimen; anal, 14; body short; adipose fin continuous with caudal; posterior part of adipose fin raylike; head, 3½; depth, 4; pectoral spine entire.

4 Catostomus teres (Mitchill) Common sucker. Sioux City, common.

5 Carpiodes velifer (Rafinesque) *Quillback; Carp sucker.* Sioux City, common.

6 Moxostoma duquesnei (Le Sueur) *Common redhorse; Mullet.* Sioux Falls, rare; Sioux City, common.

7 Hybognathus nuchalis Agassiz Silver minnow. Sioux City, rare.

8 Pimephales notatus (Rafinesque) *Blunt-nosed minnow.* Sioux Falls, common; Sioux City, rare.

9 Notropis cornutus Mock Sioux City, rare.

10 Notropis deliciosus (Girard). Abundant.

11 Notropis topeka (Gilbert). Sioux City, rare.

12 Notropis hudsonius (Dekay or Clinton) Sioux City, common.

13 Notropis whipplei (Girard) Sioux City, rare.

14 Notropis atherinoides Rafinesque. Raw minnow. Sioux City, rare.

15 Notropis megalops (Rafinesque) Common shiner. Six specimens obtained.

16 Notropis dilectus (Girard) Shiner minnow. Sioux Falls, common.

17 Hybopsis kentuckiensis (Rafinesque) Sand-pearl. Sioux Falls, common.

18 Notemigonus chrysoleucas (Mitchill) Golden shiner; Roach. Trout. Sioux City, rare.

19 Rhinichthys cataractæ (Valenciennes) Longnose dace; Lancelet horned dace. Sioux City, rare.

20 Pimephales promelas Rafinesque. Black-nosed minnow. Sioux City, Dominant.

21 Pimephales confertus Agassiz. Sioux Falls, common.

22 Pimephales vigilax (Baird & Girard) Bullhead minnow. Sioux Falls rare; Sioux City, common.

23 Ictiobus bubalus (Rafinesque). Buffalo fish. Sioux Falls, common. Sioux City, Dominant.

24 Ictiobus cyprinella (Valenciennes). Buffalo fish. Sioux Falls Sioux City. Fishermen used this name for specimens of the Big Dog and not common. Dominant.

25 Moxostoma aureolum (Le Sueur). Redhorse. Sioux Falls, common. Sioux City, dominant.

26 Catostomus nigricans Le Sueur. Sioux City, rare.

27 Catostomus commersonnii (Lacépède). Black Sucker. Sioux Falls, numerous. Sioux City, common.

28 Ictalurus lacustris (Pallas). Lake cat. Sioux Falls, rare. Sioux City, common.

29 Ictalurus punctatus (Rafinesque). Channel cat. White cat. Silver cat. Sioux Falls, rare.

30 Ictalurus punctatus (Rafinesque). Channel cat. White cat. Silver cat. Sioux City, common.

31 Ictalurus punctatus (Rafinesque). Channel cat. White cat. Silver cat. Sioux City, common.

III.—SILVER LAKE.

Silver Lake is one of the sources of the Little Sioux River. It is about 2 miles long, 1 mile wide, and very shallow, its depth seldom exceeding 6 feet. It contains very few game fishes. The larger game fishes are supposed to have been destroyed by the cold winters of a few years ago. On the northern side of the lake there is a small inlet with a very muddy bottom. We collected in the inlet and on the northern shore of the lake, where the bottom is sandy.

FISHES OF SILVER LAKE.

1. **Ameiurus melas** (Rafinesque). *Bullhead.* Abundant, especially in the inlet.
2. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow.* Common.
3. **Pimephales promelas** Rafinesque. *Flat-head.* Very abundant.
4. **Notropis megalops** (Rafinesque). *Shiner.* Not common.
5. **Notropis heterodon** (Cope). Common. Mouth small, oblique, terminal; black on tip of both jaws; back elevated; first ray of dorsal fin nearer snout than base of caudal by diameter of eye; eye, 3 in head; head, 4; depth, 4; dark band on sides; scales, 37 to 38; scales on upper part of body edged with black; lateral line incomplete.
6. **Notemigonus chrysoleucus** (Mitchill). *Golden shiner; Bream; Roach.* Abundant in the inlet.
7. **Fundulus zebrinus** Jordan and Gilbert. Abundant; with 12 to 16 bands on the sides.
8. **Lepomis megalotis** (Rafinesque). *Long-eared sunfish.* One specimen obtained; flap with pale margin; scales, 38.
9. **Etheostoma iowæ** Jordan and Meek. Common.
10. **Perca flavescens** (Mitchill). *Yellow perch.* One specimen obtained.
11. **Roccus chrysops** (Rafinesque). *White bass.* One specimen obtained.

IV.—THE SOLDIER RIVER.

The Soldier River is a small tributary of the Missouri River in western Iowa. We visited the East Fork of the Soldier River at Charter Oak, where it is a small creek with very muddy bottom. Only the following fishes were obtained.

FISHES OF THE SOLDIER RIVER.

1. **Ameiurus melas** (Rafinesque). *Bullhead.*
2. **Hybognathus nuchalis** Agassiz. *Silvery minnow.*
3. **Pimephales promelas** Rafinesque. *Fat-head.*
4. **Notropis gilberti** Jordan and Meek.
5. **Semotilus atromaculatus** (Mitchill). *Horned dace.*
6. **Lepomis cyanellus** (Rafinesque). *Green sunfish.*

V.—THE BOYER RIVER.

The Boyer River was visited at Arion Station, at which point it is a slow-flowing stream with a very muddy bottom. The water is seldom clear. But few fishes were found in the stream, but in a small bayou near by a number of species were obtained.

FISHES OF THE BOYER RIVER.

1. **Ameiurus melas** (Rafinesque). *Bullhead.* Rare.
2. **Catostomus teres** (Mitchill). *Common sucker.* Rare.
3. **Pimephales promelas** Rafinesque. *Fat-head.* Common in the bayou.
4. **Notropis deliciosus** (Girard). Abundant in the bayou.
5. **Notropis topeka** Gilbert. Common in the bayou.
6. **Notropis gilberti** Jordan and Meek. Abundant in the bayou. Scales before dorsal very small in some specimens, the number being 16 to 20.
7. **Notropis lutrensis** (Girard). Rare.
8. **Notropis megalops** (Rafinesque). *Shiner.* Abundant in the bayou.
9. **Semotilus atromaculatus** (Mitchill). *Horned dace.* Rare.
10. **Phenacobius mirabilis** (Girard). Rare. Scales, 44.
11. **Percopsis guttatus** Agassiz. *Trout perch.* Rare. Scales, 48; dorsal, XI-7 or 8.
12. **Lucius lucius** (Linnæus). *Pike; Northern pickerel.* Rare.
13. **Lepomis cyanellus** (Rafinesque). *Green sunfish.* Abundant in the bayou. The specimens obtained were mostly very small.
14. **Lepomis humilis** (Girard). *Red-spotted sunfish.* Less abundant than *L. cyanellus.*
15. **Etheostoma nigrum** Rafinesque. *Johnny darter.* Rare.

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8.—REPORT OF AN EXAMINATION OF THE RIVERS OF KENTUCKY, WITH LISTS OF THE FISHES OBTAINED.

BY ALBERT J. WOOLMAN.

INTRODUCTION.

The explorations described in this report were carried on by the writer during the summer of 1890, under instructions from the U. S. Commissioner of Fish and Fisheries, Hon. Marshall McDonald, and were executed under the direction of Dr. David S. Jordan, president of the University of Indiana. In conducting the fieldwork able assistance was rendered by Mr. Hiram W. Monical, of Brooklyn, Indiana, and Mr. Charles O. Chambers, of Van Wert, Ohio, students in the University of Indiana. The inquiry had reference to the several river basins of Kentucky, especially the head waters of the different rivers, and the fishes which inhabit them. The principal objects were to determine as fully as possible the physical characteristics and present conditions of the streams, the variety and abundance of their fishes, and such other natural-history features connected with them as might have a bearing upon fishery matters or fish-culture.

Owing to the shortness of the season, the work as originally planned could not be entirely completed. The lower Kentucky and Licking rivers received but little attention, and most of the time was spent in the mountainous parts of the State. The party being small, it was also necessary to obtain assistance along the route, but no difficulty was encountered in that respect. The people generally manifested deep interest in our investigations and did whatever they were able to advance the work. Until August 13 the writer was accompanied only by Mr. Monical, but Mr. Chambers joined the party on that date, and continued with it until the end of the season. The fieldwork was begun July 23, and was completed September 10.

A number of collections of fishes had previously been obtained in Kentucky by Dr. Charles H. Gilbert, of the University of Indiana, Dr. James A. Henshall, of the Cincinnati Society of Natural History, and Prof. Philip H. Kirsch, of Corydon, Kentucky. These collections were kindly placed at the disposition of the writer, who has made use of them in the preparation of his lists.

In the description of species all measurements are expressed in millimeters. In giving the length of specimens and comparative measurements the same should be understood to extend only to the base of the caudal fin, unless otherwise stated.

The report has been classified in accordance with the different river basins examined, as explained in the following list:

1. Rolling Fork of Salt River, at Boothe, New Haven,* and New Market.*
2. Lower Green River, Rough Creek, and Pond Creek.
3. Upper Green River:
   a. Big Barren River: The main river at Bowling Green; Drake Creek; Beaver Creek, north of Glasgow, Barren County; Little Barren River, at Osceola, Barren County.
   b. Upper Green River proper: The main river, south and east of Greensburg; Pitman Creek, northwest of Greensburg.
4. Tradewater River, at Dawson Springs.
5. Lower Cumberland River, at Kuttawa.
6. Upper Cumberland River: Clear Creek, at Wildie; Little Rockcastle River, at Hazel Patch; Rockcastle River, near Hazel Patch, 3 miles east of Livingston and at Livingston;* Cumberland River, at Barbourville; Richland Creek, near Barbourville; Smoky Fork, near Barbourville; Cumberland River, at Pineville; Straight Creek, near Pineville; Clear Fork of the Cumberland, in Whitley County;* Wolf Creek* and Briar Creek,* in Whitley County; Albany Branch,* Spring Creek,* and Indian Creek,* in Clinton County.
7. Lower Tennessee River, at Paducah.
8. Upper Tennessee River: Powell River, south of Cumberland Gap, Tennessee; Yellow Creek, at Middlesboro, Kentucky.
9. Mayfield Creek, at Hickory Grove.
10. Obion River, near Cypress.
11. Bayou de Chien, near Moscow.
12. Upper Kentucky River.
   a. South Fork, Horse Creek, near Garratsville; Goose Creek, at Garrat's salt works; Hector Creek, near Big Creek post-office; Redbird (South Fork), near Big Creek post-office; Big Creek, at Big Creek; Sturgeon Creek, near Travelers Rest.
   b. Middle Fork: Bull Creek, west of Hyden; Middle Fork, at crossing of the Hazard Road; Cutshin Creek, west of Hyden.
   c. North Fork, at Hazard; Lot Creek, west of Hazard; Troublesome Creek; Left Troublesome Creek, at Hindman.
13. Big Sandy River: Beaver Creek, at Lackey; Shelby Creek and Robinson Creek, near Robinson Creek post-office; Island Creek, east of Pikeville; Levisa Fork, at Pikeville; John Creek and Coon Creek, at Zebulon; Blain Creek, at Catalpa.
14. Licking River, at Farmers; Triplet Creek, at Farmers.
15. Little Sandy River, near its mouth.*

ROLLING FORK OF SALT RIVER.

This river was examined at a point 1¼ miles east of the railroad station at Boothe, July 24; water temperature, 76° F. Rolling Fork is one of the largest tributaries of Salt River, and rises near the central part of the State; flowing in a northwesterly direction for 100 miles, it joins Salt River 10 miles from its mouth. The station at Boothe is about 15 miles from the junction of Rolling Fork and Salt River. At the former place the stream is from 40 to 45 yards wide, and has low banks fringed with willows which overhang and shade the edges of the stream. The bottom is composed of gravel and mud, and the water is never perfectly clear, even when very low. At the time of our visit, when the stream was slightly swollen from recent rains, the water was about 2 feet deep on the rapids, with a depth of 4 to 10 feet between them. Crayfishes and unios were common, the latter attaining a very large size. *Unio multiplicatus* was the most abundant species taken and specimens frequently measured 6 to 8 inches across the shell. The land is low and studded with ridges and isolated points of knob stone of the Waverly or Lower Carboniferous group, which rise above the surrounding country to the height of 100 to 150 feet. The soil is of clay; the most common forest trees are hickory, maple (*Acer dasycarpum*), several species of oak, elm, and ash. The knobs are covered with post oak (*Quercus obtusiloba*). In addition to our examination at Boothe, collections were made in this stream by Profs. Gilbert and Swain at New Market and New Haven, in 1884.

* Localities marked by an asterisk have been visited by other collectors.

In the following list Boothe is indicated by B; New Haven by NH, and New Market by NM.

FISHES OF THE ROLLING FORK OF SALT RIVER.

1. **Noturus miurus** Jordan. *Mud cat.* (B, NH, NM.) Several small specimens were obtained.
2. **Leptops olivaris** (Rafinesque). *Mud cat; Yellow cat.* (B.) Quite common. The specimens were well marked in color, differing in a few minor points from the Western variety.
3. **Ictalurus punctatus** (Rafinesque). *Channel cat* or *Blue cat.* (B, NH.) Common, but not so plentiful as the former.
4. **Carpiodes carpio** (Rafinesque). *Carp sucker.* (B.) Common.
5. **Catostomus nigricans** Le Sueur. *Hog sucker.* (B, NH, NM.) Not common; only young specimens were taken.
6. **Moxostoma duquesnei** (Le Sueur). *White sucker.* (B, NH, NM.) Common.
7. **Campostoma anomalum** (Rafinesque). *Stone-toter.* (B.) Common. Lateral line, 52 to 55.
8. **Pimephales notatus** (Rafinesque). (B, NH.) Plentiful.
9. **Cliola vigilax** (Baird and Girard). *Bullhead minnow.* (B.) Not common.
10. **Notropis deliciosus** (Girard). (B, NM.) Common. Deeper and lighter in color than specimens from the mountainous district. No lateral band; lateral line, 36, 35, 34, 34, 36, 35; scales before dorsal, 13 to 15.
11. **Notropis whipplei** (Girard). *Blue minnow.* (B, NH, NM.) Common. Lateral line, 38, 36, 38, 35.
12. **Notropis megalops** (Rafinesque) *Common shiner.* (B, NH, NM.) Only three specimens were obtained.
13. **Notropis ariommus** (Cope). *Big-eyed shiner.* (NM.)
14. **Notropis umbratilis cyanocephalus** Copeland. (NM.)
15. **Notropis atherinoides** Rafinesque. *Rosy minnow.* (B, NM.) Not common; small, the three largest specimens taken measuring 57, 52, and 51 millimeters. Head, 4¼ in length; depth, 5 in length; lateral line, 42, 41, and 42; back somewhat compressed; no vertebral line.
16. **Ericymba buccata** Cope. (B.) Not common.
17. **Hybopsis storerianus** (Kirtland). *Spawn-eater.* (B, NH.) Common; scales, 40.
18. **Hybopsis amblops** (Rafinesque). *Silver chub.* (B.) Common; lateral line from 35 to 38.
19. **Hybopsis dissimilis** (Kirtland). *Spotted shiner.* (B.) Very rare.
20. **Semotilus atromaculatus** (Mitchill). *Chub.* (NH.)
21. **Hiodon alosoides** (Rafinesque). *Moon-eye.* (B.) Five specimens taken.
22. **Hiodon selenops** Jordan and Bean. *Southern moon-eye.* (B.) Not as common as *H. alosoides.*
23. **Dorosoma cepedianum** (Le Sueur). *Shad; Hickory shad.* (B.) Abundant.
24. **Zygonectes notatus** (Rafinesque). *Top minnow.* (B.) Rare. Specimen small; from 40 to 60 millimeters long.
25. **Lepomis megalotis** (Rafinesque). *Long-eared sunfish.* (B, NH, NM.) Not common. Taken in quiet water, under overhanging willows.
26. **Micropterus dolomieu** Lacépède. *Small-mouthed black bass.* (NH.)
27. **Etheostoma pellucidum** Baird. *Sand darter.* (B, NH.) Common. Scaled below the lateral line; scales 67 to 69.
28. **Etheostoma blennioides** Rafinesque. *Green-sided darter.* (B, NH, NM.) Only a few small specimens were obtained.
29. **Etheostoma caprodes** (Rafinesque). *Log perch.* (B, NH.) Quite common.
30. **Etheostoma phoxocephalum** Nelson. (B, NH.) Abundant. Specimens all small and light in color. This is apparently the only darter that is common in the stream.
31. **Etheostoma zonale** (Cope). (B, NH, NM.) Not common.
32. **Etheostoma cœruleum** Storer. *Rainbow darter.* (B, NH, NM.) Rare.
33. **Aplodinotus grunniens** Rafinesque. *Fresh-water drum; White perch.* (B.) Quite common. Some large specimens were taken.

LOWER GREEN RIVER.

Green River is one of the largest streams in the State and it is very deep throughout most of its course. It rises in the foothills of the mountains near the central part of the State and flows in a general westerly and northwesterly direction until it joins the Ohio River in Henderson County, 15 miles above Evansville, Indiana. At Rockport, Kentucky, some 50 or 60 miles from its mouth, it has a depth, at low water, of 20 to 25 feet. Its entire length is about 250 miles and the average width 200 to 210 yards. There is no perceptible current, a very slight breeze being sufficient to float driftwood up stream. Considering its sluggish current the water is very clear, which, together with its great depth and the abundance of small fishes, such as minnows and darters, makes it an excellent stream for food-fishes.

The banks of the stream are low and very steep, and fringed with willows, sycamores (*Platanus occidentalis*), elms, and birches (*Betula nigra*). At a distance back from the river of a quarter to a half-mile is a low line of hills with outcrops of a light sandstone. Several specimens of the young of *Necturus maculatus* were taken, and also several turtles (*Aspidonectes spinifer* and *Aromochelys odoratus*). On account of the depth of the water and the entire absence of sandbars no fishes were collected from the river proper at this place. The temperature of the water was 70° F.

1. *Pond Creek*, 2 miles from Rockport, July 25: The collecting station was one-half mile from the mouth of the creek; temperature of the water, 68° F. Pond Creek is a small southern tributary of Green River, probably about 25 miles in length, but very narrow, deep, and sluggish. The bottom is composed of fine mud, several feet deep, and the water is very impure and muddy. There is but little vegetation in the stream and but few varieties of fishes. Several specimens of the young of *Necturus maculatus* were taken, and also a few turtles, *Aspidonectes spinifer* (Le Sueur) and *Aromochelys odoratus* (Latreille).

2. *Rough Creek*, at Hartford, July 25: Collections were made below the mill, where the water temperature was 74° F. Rough Creek is one of the largest northern tributaries of Green River, rising in Hardin County and flowing in a southwesterly direction about 75 or 80 miles, where it joins the main river. Hartford, the county seat of Ohio County, is about 20 miles from its mouth. Here the channel is from 40 to 45 yards wide. At low water the stream is broken up into ponds by numerous ripples, the water being from 3 to 5 feet deep in the former and only a few inches on the latter. The ripples flow over beds of coarse gravel, while between them the bottom consists of stone with more or less mud, there being also large stones in the more quiet places, which furnish excellent hiding-places for fishes. The stream is well stocked with fish, several species of minnows and darters being especially abundant. It also furnishes a variety of good food species, such as suckers, black bass, and white perch (*Aplodinotus grunniens*). The bottom lands are low and are overflowed during high water. They are covered with gum, ash, swamp ash, black and red oak, water birch, elm, and cherry. The bed of the stream is almost devoid of vegetation.

Species marked "P," in the following list, are from Pond Creek; those marked "R" are from Rough Creek.

FISHES OF THE LOWER GREEN RIVER.

1. **Ictalurus punctatus** (Rafinesque). *Blue cat.* (R, P.) Abundant in Rough Creek.
2. **Noturus miurus** (Jordan). *Mud cat.* (R.) Reported quite common, but only a few specimens were taken.
3. **Noturus gyrinus** (Mitchill). (R.) Less common than either of the preceding; three specimens taken.
4. **Catostomus nigricans** Le Sueur. *Hog sucker.* (R.) Only three small specimens taken.
5. **Moxostoma duquesnei** (Le Sueur). *Redhorse.* (R, P.) Quite plentiful in Rough Creek.
6. **Campostoma anomalum** (Rafinesque). *Sto e-toter.* (R.) Very abundant, and much valued for bait.
7. **Hybognathus nuchalis** Agassiz. *Silvery minnow.* Common in Pond Creek and by far the most abundant minnow taken in Rough Creek.
8. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow.* (R.) Common.
9. **Notropis whipplei** (Girard). *Blue minnow.* (R, P.) Very abundant.
10. **Notropis megalops** (Rafinesque). *Shiner.* (R.) Common.
11. **Notropis umbratilis cyanocephalus** Copeland. Rare in Pond Creek, but more common in Rough Creek.
12. **Notropis atherinoides** Rafinesque. *Silvery minnow.* (R.) Common.
13. **Hybopsis storerianus** (Kirtland). *Spawn-eater.* (R.) Not common. Lateral line, 40.
14. **Hybopsis amblops** (Rafinesque). *Silver chub.* (R, P.) Common in Rough Creek.
15. **Hybopsis kentuckiensis** (Rafinesque). *Chub; Hornyhead.* Common in both streams. Specimens from Pond Creek were very large.
16. **Dorosoma cepedianum** (Le Sueur). *Mud shad.* (P.) Very plentiful in the muddy water; specimens small.
17. **Labidesthes sicculus** Cope. *Brook silverside.* (R, P.) Not common. Only a few specimens found in either creek.
18. **Aphredoderus sayanus** (Gilliams). *Pirate perch.* (P.) Very abundant. Some of the specimens have a length of 75 millimeters. Scales in five specimens, 49, 49, 50, 49, 48. Vent beneath a point about half way between the anterior edge of the dorsal and the posterior margin of opercle.
19. **Chænobryttus gulosus** (Cuv. and Val.). *War-mouth.* (P.) Common. Large; lateral line, 42, 39, 40; vent below anterior margin of dorsal.
20. **Lepomis pallidus** (Mitchill). *Blue sunfish.* (P.) Several specimens taken. Anal dusty, almost black; pectorals reaching the third anal spine; lateral line, 45.
21. **Lepomis cyanellus** Rafinesque. *Blue-spotted sunfish.* (P.) Rare. Color, dark brown; not green.
22. **Lepomis megalotis** (Rafinesque). *Long-eared sunfish.* (R.) Quite common; specimens very large.
23. **Micropterus dolomieu** Lacépède. *Small-mouthed black bass; trout.* (R.) Common, furnishing fine sport for the angler.
24. **Micropterus salmoides** (Lacépède). *Large-mouthed black bass.* (R.) Common.
25. **Etheostoma pellucidum** Baird. *Sand darter; Sand crawler.* (R.) Not common. Specimens quite dark; lateral line, 75.
26. **Etheostoma nigrum** (Rafinesque). *Johnny darter.* (R, P.) Common only in Rough Creek. Specimens not more than 58 millimeters long; lateral line, 47 to 50.
27. **Etheostoma copelandi** (Jordan). (R.) Not common. Lateral line, 45, 48, 47.
28. **Etheostoma histrio** Jordan and Gilbert. (R.) Two specimens taken, measuring as follows: Length, 28, 28; head, 6½, 6½; depth, 4½, 4½; dorsal, IX-12, X-12; anal, II-7, II-7; lateral line, 50, 52. The color agrees perfectly with the description of this species by Dr. C. H. Gilbert, in the Proc. U. S. Nat. Mus., 1887, p. 47. This is the second time that this species has been found east of the Mississippi River, as it had previously been taken by Prof. B. W. Evermann, in 1888, from the Patoka River, at Patoka, Indiana.
29. **Etheostoma shumardi** (Girard). (R.) One specimen taken. Length, 50; head, 14; depth, 9½; dorsal, XI-13; anal, II-12; lateral line, 58.
30. **Etheostoma caprodes** (Rafinesque). *Striped perch; Hickory.* (R.) Common. Lateral line, 89 or 90.

31. **Etheostoma aspro** (Cope and Jordan). *Black-sided darter.* (R.) Not common; specimens small.
32. **Etheostoma ouachitæ** Jordan and Gilbert. (R.) Not a widely distributed species. It was also taken in Indiana in 1888, by Prof. Evermann, whose specimens are a little larger than those found in Rough Creek. Five of the largest of the latter measure as follows: Length, 44 millimeters, 47, 46, 45, 43; head, 11, 12, 12, 11, 11; depth, 6, 6½, 6½, 6, 6½; lateral line, 51, 55, 52, 52, 53; dorsal, X-12, X-12, XI-12, X-12, X-12; anal, II-10, II-10, II-10, II-10, II-10.
33. **Etheostoma phoxocephalum** Nelson. (R, P.) Common; only young specimens taken.
34. **Etheostoma cœruleum** Storer. *Rainbow darter.* (P.) Rare. Three small specimens taken.
35. **Aplodinotus grunniens** Rafinesque. *White perch; fresh-water drum.* Common in both streams.

UPPER GREEN RIVER.

The Upper Green River and its tributaries flow, for the most part, over a Subcarboniferous area, cutting down to the Devonian in places. The stream is less deep here and has a good current; the banks are not so precipitous, and the bottom is covered with sand and gravel. At intervals the sand is piled up in large banks or bars, which form islands, or jut out into the river, making excellent places for collecting. Two regions were visited: (1) The Big Barren River and two of its tributaries, Drake Creek and Beaver Creek, in the neighborhood of Bowling Green, Warren County, where the surface rocks are chiefly Upper Subcarboniferous. (2) The Upper Green River proper, and one of its tributaries, Pitman Creek, on which the Lower Subcarboniferous rocks crop out.

BIG BARREN RIVER.

1. *Big Barren River*, at Bowling Green: The collecting station was three-fourths of a mile northeast of the city; water temperature, 80° F. The Big Barren River rises in Monroe County, and flows in a northwesterly direction for 75 or 80 miles to the Green River, which it joins at the northwest corner of Warren County. The stream at Bowling Green, about 20 miles from its mouth, is from 100 to 125 feet wide, clear and deep, and with considerable current. Most of the specimens were taken on or near a large shoal or sandbank above the water works. Here the bottom was of coarse gravel and sand, with a rock bottom which in the deeper places was covered with mud. There were no algæ or other water plants in the stream, but crayfishes, clams (*Unio*), and turtles (*Aspidonectes*) were common. The stream is an excellent one for fish, the water being clear and pure; the specimens taken were fine, being very active and with the colors bright and fresh. It is well stocked with good food-fishes, and contains an abundance of minnows and darters. The surrounding country is rolling and has a limestone soil, producing good crops of grain and fruit. Forest trees of ash, elm, sycamore, and birch were noticed on the banks of the river.

2. *Drake Creek:* Collections were made, August 2, 8 miles southeast of Bowling Green, just below the "Shaker Mill," and about 5 miles from the point where this creek flows into Big Barren River. The temperature of the water was 74° F. At the place visited the stream is about 15 yards wide, the bottom composed of loose, flat stones on the rapids, with stretches of mud bottom between them.

There was considerable coarse gravel or broken and rounded stones piled up at intervals, with but little sand. A species of *Veronica* and a mint were growing in large quantities in the edges of the water and shallow places; some algæ and *Fontinalis* were also noticed. The banks of the stream are from 150 to 200 feet high, the stream having cut its way to that extent through the soft spongy limestone. The creek is fed by numerous large, cold springs, the outlets of the numerous sinks of the uplands.

3. *Beaver Creek:* The examination was made about 6 miles north of Glasgow, the county seat of Barren County, August 6, the water temperature being 80° F. Beaver Creek is a small northern tributary of the Big Barren River, about 20 miles in length, and at this place, 15 miles from its mouth, is about 20 yards wide. The locality was not a good one for collecting, but is the only place for several miles where the seine could be used, on account of the mill ponds. At this point there is a short ripple about 50 yards long, between the falls of one mill dam and the back water of the one below. The stream has a considerable current over rock bottom at the ripple, but in the more quiet water the bottom is of mud. Some of the rocks were dotted with *Oscillaria*, while *Spirogyra* and other algæ were found in quiet places. The soil in the narrow valley is fertile, but the surrounding country is of a poor limestone soil, colored very red from the iron which it contains.

The banks of the stream are fringed with willows, locusts, and hawthorns (*Crataegus*). On the uplands grow red and white oak, walnut, cherry, and poplar, while the tops of the hills are covered with post oak. The soil is underlaid by a soft limestone, easily eroded, and the whole surface of the country is covered with sinks. The stream is well stocked with a variety of fishes, and the specimens taken were large and fine.

4. *Little Barren River*, at Osceola, August 6: The locality examined extended from the mill, one-half mile downstream; temperature of the water, 84° F. Little Barren River rises in the southern part of Metcalf County and flows northwesterly for about 40 miles, joining the Green River between Hart and Green counties. At this station, 5 or 6 miles from its mouth, the river is about 80 yards wide and flows over a bottom composed of stone, slate, and coarse gravel. The water on the long ripples was very shallow, being broken up into several small streams with small grassy islands between them. The low sloping bars of these islands were covered with knotgrasses and mints. Darters were found in abundance on the clear, swift ripples, while minnows and sunfishes were plentiful in the more quiet places. The station is a good one for collecting, and we obtained a fair representation of what the stream contains.

UPPER GREEN RIVER PROPER.

5. *Green River*, 5 miles southwest of Greensburg, August 7; temperature, 83° F. Here the river is about 200 yards wide, flowing over very large beds of gravel and sand. Where this material has been cut out the bottom is of smooth, flat stone, while in the deeper places some mud has been deposited. The river was fished at a ripple where the water varied in depth from 2 to 4 feet, but between the ripples the water reaches a depth of from 4 to 12 feet. The stream contained but little vegetation, which grew on the small islands or low sloping shores. The fine, smooth bars afford excellent places for collecting; not infrequently one haul of the seine would land as many as 75 darters and many more minnows and other soft-rayed fishes.

6. *Green River*, one-half mile east of Greensburg, August 8; temperature, 85°. The character of the stream here is much the same as at the last station, the distance between them being probably 8 miles by water. Fewer fishes were taken here, however, owing to the less favorable conditions for collecting, the water being swift and the ripples covered with large stones. Black bass and "Jack" (*Stizostedion vitreum*) were reported very common, although but few were taken. Forty-three species were collected at this station.

7. *Pitman Creek*, 3 miles west of Greensburg and 8 miles from the mouth of the stream; August 9; water temperature, 85° F. Pitman Creek rises in the northwestern part of Taylor County, flows in a southwesterly direction, and is about 25 miles long. At this station it is about 40 yards wide and has but few ripples. The bottom is of stone, covered in places with fine mud; at the ripples the bottom is of coarse gravel and small stones. The water is not deep, being only from 2 to 5 feet in the more quiet and deeper places. The valley is narrow, of alluvial deposits, covered with elms, sycamores, cottonwoods, and water birch. There were no *Unios*, crayfishes, or water plants in the stream. The station was not a good one for collecting, the ripple being short and deep. But few varieties of fishes were taken, the most abundant being *Ambloplites rupestris* and *Etheostoma evides*.

In the following list the different stations on the Upper Green River and its tributaries are designated as follows: Big Barren River, by B; Drake Creek, by D; Beaver Creek, by Bea; Little Barren River, by LB; Green River, 5 miles southwest of Greensburg, by G; Green River, one-half mile east of Greensburg, by GE; Pitman Creek, by P.

FISHES OF THE UPPER CREEK RIVER.

1. **Lepisosteus osseus** (Linnæus). *Common gar.* (B, G, GE.) Not common; only 4 specimens were taken.
2. **Noturus miurus** Jordan. *Mud cat.* (B, LB, P.) Not common; only young specimens were taken.
3. **Noturus eleutherus** Jordan. (GE.) This species was taken from an offshoot or bayou of the Green River at Greensburgh. The largest specimen was 55 mm. long; head, 16; depth, 10; eye, 3+; anal rays, 11; upper jaw projecting slightly. The specimens agree in all essential particulars with Dr. Jordan's description of the species.
4. **Ictalurus punctatus** (Rafinesque). *Blue cat.* (B, D, G, GE.) Common in Big Barren and Green rivers, but most abundant in the former. A much valued and very excellent food-fish, especially when taken from clear running water. Unlike most other members of the family, it prefers the running to the more sluggish water.
5. **Leptops olivaris** (Rafinesque). *Mud cat; Yellow cat.* (B, G, GE, P.) Rare in the Big Barren, but more common in the Green River. Those taken from the bayou have the colors much blended.
6. **Ameiurus natalis** (Le Sueur). *Yellow cat.* (B, GE.) Not very common; specimens dark, almost black.
7. **Ameiurus nebulosus** (Le Sueur). *Bullhead.* (B, GE.) Found only in the muddy waters of the bayou. Specimens of the *Siluridæ* were generally very scarce, being common only in the bayou at Greensburg. This bayou is a small narrow neck of water overhung with willows and with a very muddy bottom. Five species were taken there.
8. **Ictiobus bubalus** (Rafinesque). *Buffalo sucker.* (B.) Only a few young specimens taken, but reported common in the deeper waters of the Big Barren.
9. **Moxostoma duquesnei** (Le Sueur). *Common or white sucker.* Taken at every station, and common at nearly all of them. Some very large specimens were obtained in the Big Barren, where it was particularly abundant.

10. **Catostomus nigricans** (Le Sueur). *Hog sucker.* The young were abundant at every station.
11. **Minytrema melanops** (Rafinesque). *Striped sucker.* (Bea.) Found only at one station. Four specimens were taken, 3 small and 1 large. The lateral line was complete in the young and entirely absent in the adult. Scales 46.
12. **Campostoma anomalum** (Rafinesque). *"Dough-belly."* Common at every station, but most abundant in the headwaters of rivers.
13. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow.* (B, D, Bea.) Common at the first two stations named, but only a few taken at the last.
14. **Hybognathus nuchalis** (Agassiz). *Silvery minnow.* (Bea.) Not common; sides not punctate.
15. **Notropis deliciosus** (Girard). (GE.) A very widely distributed minnow, but taken at only one place in the Green River system. Rare.
16. **Notropis whipplei** (Girard). *Blue minnow.* Taken at every station; found abundantly in nearly all the streams in this section, but more abundant in the larger ones.
17. **Notropis megalops** (Rafinesque). *Silverside; Shiner.* Taken at every station, but much more common in the Big Barren and its tributaries than in the Green River; only a few very young specimens were taken in the latter.
18. **Notropis ariommus** (Cope). *Big-eyed shiner.* (B, LB, G, GE, D.) Not found in the streams farther west, but not uncommon in the Upper Green River and its tributaries. The specimens agree in most particulars with Cope's description* of *Photogenis ariommus*, especially in the broad faint lateral band, but the specimens from the Green River have a dark vertebral band. The largest specimens from Drake Creek measured 70 millimeters long; head, 16; depth, 16; eye, 5½; anal rays, 9; lateral line, 37; snout very short, little more than half of eye. Twelve specimens were taken at the first station on the Green River, six of which measured as follows (in millimeters):

Length.	Head.	Eye.	Lateral line.	Eye in head.
61	16	7	40	2.3
61	16	7	39	2.3
59	15.5	6.5	39	2.3
54	15	6.5	40	2.3
60	16	7	36	2.3

19. **Notropis umbratilis cyanocephalus** (Copeland). *Redfin.* Taken at every station except Pitman Creek, and generally common. No variation noticed except in color.
20. **Notropis dilectus** (Girard). *Emerald minnow.*

Alburnus rubrifrons Cope, Proc. Acad. Nat. Sci. Phila. 1865, p. 85.

Leuciscus rubrifrons Günther, VII, 225. (B, D, G, GE.) Common at the stations named and very abundant in Drake Creek. A very handsome little minnow, varying in color in different localities. In this region it is of a very dark olive-green above, with a wide, thin, silvery lateral band, overlying a very dark plumbeous stripe that is sharply defined, especially on its upper margin. Vertebral band distinct; caudal peduncle slender. Careful measurements of several specimens from different localities in this creek system show but little variation. Specimens from this locality are much more slender than those described by Cope from the Alleghany region; his measurement of depth in length, including caudal fin, was only 5.5. Six specimens from Drake Creek measure as follows (in millimeters):

Length.	Depth.	Head.	Eye.	Anal rays.	Lateral line.	Head in length.	Depth in length.	Eye in head.
49	9	11+	4	10	37	4.45	5.44	2.75
49	8.5	11	4	10	38	4.45	5.16	
49	9	11.5	4	10	40	4.26	5.44	2.75
49	9	11	4	10	37	4.24	5.22	
47	8.5	11	4−	10	37	4.24	5.25	
48	9	12	4+	10	38	4	5.33	

* Synopsis Cyprinidæ of Pennsylvania, p. 378.

21. **Notropis atherinoides** Rafinesque. *Rosy minnow.* Taken at all the stations except Beaver Creek; more abundant in the larger streams.

Length.	Head.	Depth.	Eye.	Anal rays.	Lateral line.
68	16	11	6	11	39
75	18	13	7	11	38
74	18	14	7	11	40

22. **Notropis arge** (Cope). Common in large clear streams. I have followed Professors B. W. Evermann and O. P. Jenkins in the indentification of this species, but find some variation between what we have called *arge* and Cope's *Alburnellus arge*, described in his Synopsis of the Cyprinidæ of Pennsylvania. Cope gives the length of *A. arge* as 2.75 inches, less than that of *atherinoides* (*Alburnellus jaculus*), while the specimens I have examined have generally been much larger. Cope describes the lateral line of *A. arge* as straight, which is not true in what we recognize as *N. arge*. The silver band on the sides of *N. arge* extends below the lateral line, while the interorbital space is about equal to the orbit.
23. **Notropis** sp. (LB.) Not common.
24. **Notropis telescopus** (Cope). (LB.) Rare.
25. **Phenacobius uranops** Cope. (B, D, G, GE.) Not common. No caudal spot; lateral line, 60.
26. **Hybopsis hyostomus** Gilbert. (B, LB, G, GE.) Not rare. Found in clear water, ordinarily in the swift water of the ripples. The largest specimen from Green River measured 57 mm. long; lateral line, 39.
27. **Hybopsis amblops** (Rafinesque). *Silver chub.* (G, GE, P.) Not common, being poorly represented at each station.
28. **Hybopsis watauga** Jordan and Evermann. (B, LB, D, G, GE.) Very abundant in the clear swift water of Big Barren River and Drake Creek. The scales in the lateral line of a few specimens are as follows: 48, 47, 48, 50, 49. 51, 49, 50. Scales before dorsal, 20 and 21. The scales in the lateral line of *H. dissimilis* (Kirtland) are 43, 44, 47, 46, 43, 45, 46, 44; scales before dorsal, 17, 17, 18, 17, 17, 16, 16. The large spots, so conspicuous on the sides of *H. watauga*, are a distinguishing feature. *H. watauga* is ordinarily much larger than *H. dissimilis*, and often reaches 100 mm. in length.
29. **Hybopsis kentuckiensis** (Rafinesque). *Chub.* (B, LB, D, GE.) Common. Lateral line, 42 to 44.
30. **Semotilus atromaculatus** (Mitchill). *Hornyhead.* (D, Bea.) Not common. Lateral line, 57.
31. **Hiodon selenops** Jordan and Bean. *Moon-eye.* (P.) Very rare; only one specimen was taken.
32. **Zygonectes notatus** (Rafinesque). *Top-minnow.* (D.) Rare; only three very small specimens were obtained.
33. **Fundulus catenatus** (Storer). *Studfish.* (GE.) Very rare.
34. **Labidesthes sicculus** Cope. *Brook silverside.* (B, D, LB, G, GE.) Found to be most abundant about the large sandbars in Green River; only a few were taken in Big Barren River.
35. **Pomoxis annularis** Rafinesque. *Calico bass.* (B, G, B, GE.) Not common in the Big Barren; abundant in the bayou of the Green River. Specimens very large.
36. **Ambloplites rupestris** (Rafinesque). *Goggle-eye.* (LB, G, GE, P.) Small specimens common in the bayou of the Green River; several large ones taken in Pitman Creek.
37. **Lepomis pallidus** (Mitchill). *Blue sunfish.* (GE.) Very rare. Lateral line, 44.
38. **Lepomis megalotis** (Rafinesque). *Long-eared sunfish.* Very generally distributed, but not many specimens were taken at any one station.
39. **Micropterus dolomieu** Lacépède. *Small-mouthed black bass.* Taken in all streams visited and plentiful in all the larger ones.
40. **Micropterus salmoides** (Lacépède). *Large-mouthed black bass.* Not nearly so common as *M. dolomieu.*
41. **Etheostoma nigrum** (Rafinesque). *Johnny darter.* (B, D, GE.) Common in Big Barren River and Drake Creek, but only a few small specimens obtained in the Green River. Lateral line, 48, 48, and 44.

42. Etheostoma blennioides Rafinesque. *Green-sided darter.* (B, LB, D.) Common in the Big Barren River and Drake Creek, and the most abundant darter in the Little Barren River. A few very small specimens were taken at the first station on the Green River and several large ones at the second station.

43. Etheostoma pellucidum Baird. *Sand darter.* (G, GE, LB.) Common only at the first station on the Green River, where about 75 specimens were taken. These specimens varied considerably both in color and squamation.

44. Etheostoma asprellus (Jordan). (G, GE.) Not widely distributed, nor common anywhere. Lateral line, 96.

45. Etheostoma copelandi (Jordan). (G, GE.) Very abundant at the first station on the Green River and common at the second. *E. copelandi* and *E putnami* are closely allied, and may be identical, the chief differences occurring in the number of spines in the dorsal and anal fins and in the size of the scales. *E. copelandi* has dorsal XI-10; anal II-9; lateral line, 56. *E. putnami* has dorsal, X-11; anal, II-8; lateral line, 44. In thirteen specimens from this locality the dorsal is X-11, X-12, XI-11, XI-10, X-11, XI-12, X-11, X-12, X-12, X-12, X-12, X-11, X-12; anal, II-9, II-8, II-9, II-9, II-8, II-8, II-8, II-9, II-9; lateral line, 51, 48, 51, 49, 52, 51, 50, 48, 51, 48, 50, 50, 54. In these specimens the lateral line does not go as high as the average given for *E. copelandi*, nor as low as in *E. putnami*, while the number of fin rays seems to indicate nothing. I was also unable to find any constant difference in the relative proportion of head and depth.

46. Etheostoma caprodes (Rafinesque). *Log perch; Jack minnow; Hickory.* (B, D, LB, G, GE.) Not so abundant as in the western part of the State.

47. Etheostoma macrocephalum (Cope). (B, LB, D, Bea, G, GE.) A large handsome darter, but little known and not widely distributed. Rather plentiful in the Holston, but more abundant probably in this region than any other yet visited by the collector. The measurements of a few of the largest specimens are as follows:

Length.	Head.	Depth.	Eye.	Lateral line.	Dorsal.	Anal.
73	21	11	5	81	XII-13	II-11
69	20	11	4.5	83	XII-13	II-11
64	19	10	4	82	XII-13	II-11
65	19	10	4	83	XII-12	II-11

Three of the largest specimens out of twelve taken from the second station on the Green River measure as follows:

Length.	Head.	Depth.	Eye.	Lateral line.	Dorsal.	Anal.	Remarks.
70	20 5	12	5	79	XII-13	II- 9	Cheeks with a few irregular patches of scales.
69.5	20	12	5	83	XIV-14	II-10	
65	19.5	10	5	79	XV-13	II-10	

48. Etheostoma aspro (Cope and Jordan). *Black-sided darter.* (B, G.) Not abundant. Several specimens were taken from the Big Barren River, and only two from the Green. Lateral line, 62, 68, 65.

49. Etheostoma phoxocephalum Nelson. (D, G, P.) Not common. Only one small specimen taken from Pitman Creek.

50. Etheostoma cymatotænia Gilbert and Meek. (B, D, Bea, LB, G, GE.) A very rare darter, related to *E. macrocephalum*, never before taken east of the Mississippi River.* A few of the largest specimens measure as follows:

Length.	Head.	Depth.	Eye.	Lateral line.	Dorsal.
42	12	7+	3	63	XII-12
49	13	9	4.5	60	XII-13
44	12	7.5	4	62	XII-12
55	15	10	4.5	61	XII-12

51. Etheostoma scierum (Swain). (B.) Rare, only one specimen having been obtained.

52. Etheostoma simoterum (Cope). Very rare, specimens all young.

53. Etheostoma evides Jordan and Copeland. (C, G, GE, P.) Common only at Pitman Creek, where it was taken in abundance; most of the specimens, however, were small. Compared with specimens from White River, Indiana, they were not so deep in proportion to their length; stripes more narrow and not so well defined; back less elevated, and scales smaller. Twelve specimens afforded the following measurements: 58, 63, 62, 69, 59, 62, 61, 63, 63, 62, 60, 61. Pectorals unmarked.

54. Etheostoma zonale (Cope). (B, LB, Bea, G, GE.) Common wherever taken; most abundant in the clear ripples of the larger streams. The dark-green markings on the sides not arranged in well-defined bars; pectorals crossed by faint-green bars; cheeks with irregular patches of scales; lateral line from 56 to 62.

55. Etheostoma camurum (Cope). (G, GE.) Neither distributed generally nor taken in large numbers. Always found in swift water. General color brown, with a number of faint, narrow, green lines running longitudinally, and broader ones running vertically; 20 or 30 small orange spots, about one-half millimeter in diameter, scattered promiscuously over the sides, numerous on the caudal peduncle. Two specimens from the first station on Green River were 43 and 45 millimeters long; scales in lateral lines, 48 and 53. Two from the second station measured 45, 47; scales, 49, 41.

56. Etheostoma rufolineatum (Cope). (B.) Rare. Color, light olive, striped with brown and green, with a few orange spots on caudal peduncle and about mouth and cheeks; dorsal light, bordered with the same orange color.

57. Etheostoma flabellare (Rafinesque). (G, GE.) Not common.

58. Etheostoma cœruleum Storer. *Rainbow darter.* (B, Bea, LB, G, GE.) Common.

59. Etheostoma stigmæum (Jordan). *Speck.* (B, LB, D, G, GE.) Widely distributed and very abundant at all the stations. According to Dr. Gilbert, the types of *Etheostoma stigmæum* are identical with those of *E. saxatile.*

60. Etheostoma virgatum (Jordan). Rare.

61. Etheostoma microperca Jordan and Gilbert. *Least darter.* (LB.) Very rare.

62. Stizostedion vitreum (Mitchill). *Jack; Jack salmon; White-eye.* (G, GE, P.) Most common in the Green River. A very excellent food-fish.

63. Aplodinotus grunniens (Rafinesque). *Fresh-water drum; White perch; Campbellite.* (B, GE.) Common in Big Barren River; much valued as food.

64. Cottus bairdi Girard. *Miller's thumb.* (LB.) Rare.

* A full description can be found in a paper entitled "New and Little-known Etheostomoids," by Dr. C. H. Gilbert; Proc. U. S. Nat. Mus. 1887, 51.

TRADEWATER RIVER.

Tradewater River rises in Christian County, Ky., and flows in a northwesterly direction to the Ohio River, which stream it joins in Union County, 60 miles above Paducah. It is about 70 miles long, flowing for most of its length just inside of the western coal region. Dawson Springs is probably 45 miles from its mouth. The stream at this place is from 20 to 30 yards wide; the banks are low and steep, without sand or gravel. The bottom is composed almost entirely of mud, but there is an outcrop of rock at the mill affording a rocky bottom for a few yards. The river is warm and sluggish, and never very clear, apparently not receiving a very large supply of spring water, although several springs were noticed at the mill. It is well stocked with several varieties of fishes, one of the most abundant being the small-mouthed black bass, or "trout", as it is commonly called in Kentucky. This locality is not favorable for collecting, as the stream is full of logs, brush, and roots. The examination was made at the mill, one-half mile southeast of Dawson, and at the railroad bridge, three-quarters of a mile south of Dawson, July 26; water temperature, 82° F.

FISHES OF THE TRADEWATER RIVER.

1. **Lepisosteus osseus** (Linnæus). *Common garfish.* Very abundant, as many as four, measuring from 2 to 3 feet long, being taken at one haul of the seine.
2. **Lepisosteus platystomus** (Rafinesque). *Duck-billed gar.* Not so common; only one specimen was taken.
3. **Carpiod·s carpio** (Rafinesque). *Carp sucker.* Several specimens were taken.
4. **Catostomus nigricans** (Le Sueur). *Hog sucker.* Not common. Scales, 47.
5. **Erimyzon sucetta oblongus** Mitchill. *Striped sucker.* Only one specimen taken. Lateral line, 47.
6. **Moxostoma duquesnei** (Le Sueur). *Common sucker, redhorse.* Common.
7. **Campostoma anomalum** (Rafinesque). *Dough-belly.* Rare. Specimens all small.
8. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow.* Abundant.
9. **Notropis deliciosus** (Girard). Not common. Three specimens were taken, the largest measuring 54 millimeters. A faint spot before dorsal; snout broad, with a dark band passing around it; eye, 2¾ in head; lateral line, 34; 13 scales before dorsal.
10. **Notropis megalops** (Rafinesque). *Shiner.* Rare; five specimens taken.
11. **Notropis umbratilis cyanocephalus** Copeland. Quite common. Spot before dorsal indistinct.
12. **Notropis atherinoides** (Rafinesque). *Silvery minnow.* Common. The largest measured as follows: Length, 80 millimeters; head, 16; depth, 15; eye, 5½; lateral line, 40. Silvery band extending above the lateral line over 2½ rows of scales.
13. **Hybopsis amblops** (Rafinesque). *Silver chub.* Not common. Largest specimen 56 millimeters in length.
14. **Zygonectes notatus** (Rafinesque). *Top minnow.* Rare; specimens all small.
15. **Labidesthes sicculus** Cope. *Brook silverside.* One specimen taken.
16. **Anguilla chrysypa** Rafinesque. *Common eel.* Common. Several specimens measuring at least 2 feet in length were taken.
17. **Pomoxis annularis** Rafinesque. *Crappie.* Common.
18. **Lepomis megalotis** (Rafinesque). *Long-eared sunfish.* Abundant.
19. **Lepomis pallidus** (Mitchill). *Blue sunfish.* Rare.
20. **Lepomis macrochirus** Rafinesque. Two specimens taken. Length, 67 and 63 millimeters; depth, 28 and 25; head, 24 and 21. Dorsal spines high and rather slender; pectorals reaching third anal spine. The bars of bright orange spots were quite conspicuous in life, but fading in spirits, so that they are scarcely visible. Scales in lateral line, 41 and 42.
21. **Micropterus dolomieu** Lacépède. *Small-mouthed black bass.* Probably the most abundant of all the spiny-rayed fishes.
22. **Micropterus salmoides** (Lacépède). *Large-mouthed black bass.* Not so common as *M. dolomieu.*

23. **Etheostoma nigrum** (Rafinesque). *Johnny darter.* Common. Lateral line, 50, 48, 47, 49, 50.
24. **Etheostoma aspro** (Cope and Jordan). *Black-sided darter.* Common; only small specimens taken.
25. **Etheostoma phoxocephalum** Nelson. Rare.
26. **Etheostoma fusiforme** (Girard). Only one specimen taken. Length, 20 millimeters; head, 8; depth, 5; lateral line, 47; 21 scales with tubes; dorsal, X–11; caudal peduncle long and slender; color light, mottled with brown, apparently without any regularity.

LOWER CUMBERLAND RIVER.

This part of the Cumberland River was examined 1¼ miles south of the town of Kuttawa, Kentucky, July 26. The temperature of the water was 82° F. At this point the river runs over a broad sandbank half a mile long, that extends nearly across it. It was the only place in this part of the country where the river could be fished successfully with a small seine, the banks being generally precipitous and the water deep. The sand on the bar was covered in the more quiet water with fine mud a few inches deep, but nowhere was any vegetation found in the stream. Unios and crayfishes were taken, but they were not abundant. A few sunfishes and bass were obtained from a small artificial lake west of the river, but as the river frequently overflows into this lake I have included these with the river species.

FISHES OF THE LOWER CUMBERLAND RIVER.

1. **Acipenser rubicundus** Le Sueur. *Sturgeon.* Common; several specimens taken.
2. **Lepisosteus osseus** (Linnæus). *Common gar.* Four specimens taken.
3. **Ictalurus punctatus** (Rafinesque). *Channel cat,* or *Blue cat.* Quite plentiful, and one of the most valued food-fishes at this place.
4. **Ictiobus bubalus** (Rafinesque). *Small-mouthed buffalo.* Common; specimens taken were small.
5. **Carpiodes difformis** Cope. Common.
6. **Catostomus nigricans** Le Sueur. *Hog sucker.* Not abundant.
7. **Moxostoma duquesnei** (Le Sueur). *Redhorse; White sucker.* Quite common; lateral line, 44.
8. **Cycleptus elongatus** (Le Sueur). *Black horse.* One young specimen taken.
9. **Campostoma anomalum** (Rafinesque). *Dough-belly.* Not common.
10. **Hybognathus nuchalis** (Agassiz). *Silvery minnow.* A very common minnow.
11. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow.* Only a few specimens taken.
12. **Cliola vigilax** (Baird and Girard). *Bull-head minnow.* Rare; lateral line, 43.
13. **Notropis whipplei** (Girard). *Blue minnow.* One of the most abundant of the minnows, apparently preferring clear, running water.
14. **Notropis jejunus** (Forbes). Common. Two of the largest specimens taken afford the following measurements: Length, 50 and 52 millimeters; head, 12 and 12.5; depth, 12 and 12; lateral line, 32 and 33; scales before dorsal, 15. Snout broad and dusky; back somewhat elevated, with dark vertebral stripe; caudal peduncle wide; side with a broad, silvery lateral band.
15. **Notropis megalops** (Rafinesque). *Shiner.* Quite common.
16. **Notropis atherinoides** Rafinesque. *Silvery minnow.* Measurements (in millimeters) of five of the largest are as follows:

Length.	Head.	Depth.	Lateral line.	Anal rays.
65	13	13	37	10
63	13.5	12	38	11
71	15.5	14	38	11
68	14.5	13.5	37	11
66	14	13	38	11

Making head in length 4.7, 4.6, 4.58, 4.68, 4.6; and depth in length, 5, 5.25, 5, 5, 5; back compressed; color light.

17. **Hybopsis storerianus** (Kirtland). *Spawn-eater.* Common; the specimens were large.
18. **Opsopœodus emiliæ** Hay. One specimen was taken. It has a clear, well-defined, black lateral band, 1 millimeter wide, which passes around the snout and touches the lower lip, leaving two black spots, and passing back well over the caudal rays. There is also a well-defined vertebral band; dorsal dusky, and anal black at base.
19. **Hiodon alosoides** (Rafinesque). *Moon-eye.* One specimen taken. Length, 170 millimeters; depth, 45; lateral line, 60; dorsal rays, 9.
20. **Dorosoma cepedianum** (Le Sueur). *Mud shad.* Quite common, especially in the lake. Length from 50 to 70 millimeters.
21. **Zygonectes notatus** (Rafinesque). *Top-minnow.* Not common.
22. **Fundulus catenatus** (Storer). *Studfish.* Not common. The largest specimen measures 61 millimeters.
23. **Gambusia patruelis** (Baird and Girard). Not common; taken only in the lake.
24. **Labidesthes sicculus** Cope. *Brook silverside.* Common.
25. **Lepomis megalotis** (Rafinesque). *Long-eared sunfish.* Found very abundant in the lake, and also taken in the river.
26. **Lepomis cyanellus** Rafinesque. *Green sunfish.* Found only in the lake. Lateral line, 45.
27. **Lepomis pallidus** (Mitchill). *Blue sunfish.* Taken in both the river and the lake; very abundant in the latter; specimens very dark. Lateral line, 38 to 41.
28. **Micropterus dolomieu** Lacépède. *Small-mouthed black bass.* Common; abundant in the lake.
29. **Micropterus salmoides** (Lacépède). *Large-mouthed black bass.* Less common than *M. dolomieu.*
30. **Etheostoma pellucidum** Baird. *Sand darter.* Common, but taken only in the river.
31. **Etheostoma shumardi** (Girard). Not common. Eleven dark bands on sides, and a dark curved line back of opercle. Lateral line, 58.
32. **Etheostoma phoxocephalum** Nelson. Common. Specimens small, light in color.
33. **Etheostoma caprodes** (Rafinesque). *Log perch.* Common. Lateral line, 90, 91, 89, 90; specimens, large.
34. **Etheostoma aspro** (Cope and Jordan). *Black-sided darter.* Rare; only three specimens taken from river.
35. **Stizostedion vitreum** (Mitchill). *Jack; Jack salmon.* Common in the river.
36. **Roccus chrysops** (Rafinesque). *White bass.* Common. Lateral line, 60.
37. **Aplodinotus grunniens** Rafinesque. *Fresh-water drum; White perch.* Common.

UPPER CUMBERLAND RIVER.

The Upper Cumberland River was examined in Rockcastle, Laurel, and Knox counties, just within the mountains, and consequently in the eastern coal region. The streams in this part of the country have cut deep through strata of sandstone, shale, and slate, so that the banks on either side rise high and steep, leaving, however, in some places, a narrow strip of level land near the water. The streams are swift, flowing almost entirely over rocky beds with, here and there, banks of small eroded stones and gravel, but in some of the more quiet places the bottom is muddy. The water is clear and cold, with considerable current at all times. Unios and crayfishes were scarce; no algæ were found, and but little vegetation of any kind was noticed in the stream. A species of mint, however, was found along the edges of the water and in the more shallow ripples. No great variety of fishes was noticed, the more active and alert varieties being by far the most common. Small species, and especially the soft-rayed fishes, were very scarce. The sides of the mountains are covered with a heavy growth of hard-wood timber, such as ash, oak, beech, and tulip tree (*Liriodendron tulipifera*). Examinations were made at the following localities:

1. *Clear Creek*, near Wildie, 1 mile west of the railroad station, which is 10 miles northwest of Livingston, on the Kentucky Central Railroad; temperature of the water, 72° F. Clear Creek is tributary to Round Stone, and this again to the Rockcastle River. Round Stone receives Clear, Brush, and Crooked creeks above the "Sinks," and, after flowing under ground for a distance of 4 miles, joins the Rockcastle River at the "Boils," near Livingston. Clear Creek is a smooth, open stream, offering a good opportunity for collecting. It is not more than 20 miles long, and throughout its lower course is about 10 yards wide. The crooked valley through which it flows is narrow and low, the immediate banks being but a few feet above the water, so that they are easily overflowed. The water is quite clear. The ripples are short and shallow, flowing over piles of gravel, between which the depth is nearly uniform (about 3 feet) and the bottom bed of rock. Little or no vegetation was found growing in the bed of the creek; the banks were lined with willows, sycamores, and cottonwoods. The stream contains an abundance of fishes, such as bass, suckers, and minnows, *Campostoma anomalum* being the most abundant. *Notropis megalops* and *Notropis umbratilis* were also very abundant.

2. *Little Rockcastle River*, 6 miles northeast of Livingston, August 12; water temperature, 62° F. Little Rockcastle River is a small, shallow, but comparatively wide stream, tributary to Rockcastle River; a number of coal shafts open into its valley. The bed of the stream is covered in places with the slack coal from the mines, to a depth of 1 to 3 feet, and this in turn is sometimes covered with sand, through which the collector makes his way with difficulty. The water has a decided bluish tinge, caused probably by the copperas ($FeSO_4$) from the mines. The stream was seined in several places, but not a specimen of fish was taken or seen, the stream seeming to be devoid of both animal and vegetable life, due probably to the poisonous salts of iron.

3. *Rockcastle River*, one-half mile above the mouth of the Little Rockcastle River, August 12; water temperature, 64° F. The Rockcastle River rises in the mountains of Jackson County, flows southwesterly 50 or more miles to the Cumberland, and is the largest northern tributary of that river coming from the mountains. It has all the characteristics of a mountain stream, being swift, rocky, and in places deep. The hills on either side are composed principally of sandstone, which, during heavy rains, split off in large land-slides and fall into the water. At this station the river is 25 or 30 yards wide, and rushes over a very rocky ripple. The water was from 2 to 3 feet deep, being slightly swollen by recent rains. Near the shore were a few small sand-banks, on which grew some wild grasses and mints. No unios or crayfishes were taken, and but few fishes. The stream is a favorite resort for the angler, black bass being taken in large numbers.

4. *Rockcastle River*, 2 miles from Livingston, August 13; water temperature, 63° F. The character of the stream was much the same as at the last station above described. It was not, however, a good place for collecting. More soft-rayed fishes were taken here than at the former place, suckers (*Moxostoma duquesnei*) being comparatively plentiful.

5. *Cumberland River* at Barbourville, August 14; water temperature, 62° F. Collections were made just south of the town, both above and below the mill. The stream at this point, 80 miles above the falls, is more than a hundred yards wide, rapid and rocky. The deeper places have a smooth rock bottom, with a greater or less

quantity of large, loose sandstones scattered over it. The ripples were very rocky and the water was very swift. Only a few species of fishes were taken, bass and sunfishes being the most common. A few varieties of minnows were also comparatively plentiful. The soil is composed of a yellow clay; the bottom lands, where they are uncleared, are covered with willows, birch (*Betula nigra*), elms, and cottonwoods (*Populus monilifera*).

6. *Richland Creek*, 1½ miles west of Barbourville and near the mouth of Smoky Fork, August 14; water temperature, 68° F. The creek is small, only about 15 miles long, and at this point about 25 feet wide. It is quite rapid, flowing over a rocky bottom which is covered with mud in places. The water is from 1 to 4 feet in depth. But few species of fishes were taken.

7. *Smoky Fork*, a small tributary of Richland Creek, was fished half a mile from its mouth. This stream has a sandy bottom, and the deeper water stood in small deep pools. The chub (*Hybopsis kentuckiensis*) was the most abundant species obtained.

8. *Cumberland River*, Pineville, August 15; water temperature, 65° F. The examination was made just below the bridge between the railroad station and the town. At this place the river flows over a fine ripple more than a quarter of a mile long. The bottom of the ripple is comparatively smooth, composed of well-worn sandstones, partially imbedded in gravel and shale, with a few small bars of sand near the shore. The imbedded stones were fringed with an alga and *Fontinalis*. The water was swift and of a uniform depth, about 2 feet. This place offered the best facilities for collecting that were found in the river, but fish were very scarce. Black bass and goggle eye were the most common species, but even these were not plentiful. Haul after haul was made without securing a single soft-rayed fish, but a few specimens of *Ericymba buccata* were taken.

9. *Straight Creek*, Pineville, August 15; water temperature, 67° F. The collecting station was 2 miles above the mouth of the creek. Straight Creek is about 30 miles long, flowing just at the foot of, and parallel with, the Pine Mountains, and joins the Cumberland River at Pineville. It is neither rapid nor deep, but very broad and shallow for a mountain stream. The banks are low, but steep; the bed of the creek is composed principally of sand, with large sandstones lying loose in the stream. The deepest water is not more than 5 feet, while in the more shallow places sandbars rise to the surface. The stream is a good one for collecting in, and was seined thoroughly for nearly a mile, but with little success. Only a small number of species and but few specimens were taken. The only soft-rayed fish obtained in any number was *Notropis whipplei*.

It is noticeable that fishes were more abundant in the Rockcastle River and its tributaries than in the Upper Cumberland and its tributaries. The reason for this is, probably, that the Rockcastle joins the Cumberland below the falls.

In the following list of fishes, Clear Creek is designated by the letters Cl; Rockcastle River, by R; Richland Creek, by Ri; Smoky Fork, by S; Cumberland River at Barbourville, by CB; Cumberland River at Pineville, by CP; and Straight Creek, by St. Species marked with an asterisk (*) were collected in the Rockcastle River just below the railroad bridge, by Dr. Charles H. Gilbert, in 1884; those marked with a dagger (†) were obtained in the same river near Livingston, by Drs. Jordan and Gilbert, in 1876.

FISHES OF THE UPPER CUMBERLAND RIVER AND ITS TRIBUTARIES.

1. **Ameiurus nebulosus** (Le Sueur). *Common bullhead.* (CP.) One large specimen taken.
2. **Leptops olivaris** (Rafinesque). † *Mud cat; Yellow cat.* (CB.) Not common.
3. **Catostomus nigricans** (Le Sueur). *† *Hog sucker.* Taken at every station; abundant in Clear Creek and Richland Creek, but rather rare in other places.
4. **Catostomus teres** (Mitchill). † *Fine-scaled sucker.* (R, S.) Rare; only two specimens taken.
5. **Moxostoma duquesnei** (Le Sueur). *† *Common sucker.* Taken at every station and very abundant in Clear Creek.
6. **Lagochila lacera** (Jordan and Brayton). *Hare-lip.* (Cl, R.) Not widely distributed; abundant in Clear Creek.
7. **Erimyzon sucetta** (Lacépède). † *Chub sucker.*
8. **Campostoma anomalum** (Rafinesque). *† (Cl, R, CB, Ri, St.) Very abundant in Clear Creek; common at most of the other stations except Straight Creek. One specimen from Straight Creek measured as follows: Length, 75 millimeters; head, 13; depth, 13; teeth, 1, 4–4, 1; lateral line, 1.52. Snout broad and blunt. Color dark, gradually shading to light below; a very dark line behind opercle and under eye.
9. **Pimephales notatus** (Rafinesque). † *Blunt-nosed minnow.* (Cl, R, CB.) Common. One of the most common minnows at the stations named.
10. **Notropis deliciosus** (Girard). *† (R, CB, St.) Common at the first station on the Cumberland; one specimen only was taken in Straight Creek.
11. **Notropis spectrunculus** (Cope). (CB.) Only five specimens taken.
12. **Notropis whipplei** (Girard). * *Blue minnow.* Taken at every station except the second one on the Cumberland. Very abundant in Clear Creek. All the specimens from these clear mountain streams were especially fine and brightly colored.
13. **Notropis galacturus** (Cope). † *Milky-tailed shiner.* (Cl, R.) Not widely distributed, but abundant where taken. At Clear Creek it was much more common than *N. whipplei;* also quite common in Rockcastle River.
14. **Notropis megalops** (Rafinesque). *Common shiner.* Taken at all stations except the second on the Cumberland; common in Clear and Smoky creeks.
15. **Notropis umbratilis cyanocephalus** Copeland. *† *Redfin.* (Cl, CB, CP, Ri, S, St.) Common in Clear and Richland creeks.
16. **Notropis dilectus** (Girard). * (R.)
17. **Notropis atherinoides** Rafinesque. * *Silvery minnow.* Rather common. L., 59, 62, 62, 58, 55, 71.
18. **Chrosomus erythrogaster** (Rafinesque). † *Red-bellied dace.*
19. **Ericymba buccata** Cope. (CB, Ri, S, St.) Common only at the first station on the Cumberland; several specimens were taken in Richland and Smoky creeks, but only two in Straight Creek. Specimens all small.
20. **Semotilus atromaculatus** (Mitchill). *† *Chub; Horned dace.* (CB, Ri, S.) Common only in Richland and Smoky creeks, and much more abundant in the latter, which is the more sluggish stream. Lateral line, 52 to 56.
21. **Hybopsis amblops** (Rafinesque). *Silver chub.* (CB.) Common.
22. **Hybopsis kentuckiensis** (Rafinesque). * *Chub; Hornyhead.* (Cl, R, CB.) Common.
23. **Phenacobius uranops** Cope. *† (R.) Rare. Lateral line, 58 to 60.
24. **Anguilla chrysypa** Rafinesque. † *Eel.*
25. **Fundulus catenatus** (Storer). *Studfish.* (St.) Only one specimen taken.
26. **Ambloplites rupestris** (Rafinesque). *Rock bass; Goggle-eye.* (CB, CP.) Relatively common.
27. **Lepomis megalotis** (Rafinesque). *† *Long-eared sunfish.* (Cl, R, S, CB, Cp, St.) Common in Clear Creek and at the first station on the Cumberland.
28. **Lepomis pallidus** (Mitchill). † *Blue sunfish.*
29. **Lepomis garmani** Forbes. (CB.) Rare.
30. **Lepomis cyanellus** Rafinesque. *Green sunfish.* (S.) Very rare.
31. **Micropterus dolomieu** Lacépède. *"Trout;" Small-mouthed black bass.* Abundant at every station except Straight Creek.
32. **Micropterus salmoides** (Lacépède). *Large-mouthed black bass.* (CB.) Not nearly so common as *M. dolomieu.*

33. **Etheostoma pellucidum** Baird. *Sand darter.* (St.) The most common darter wherever taken.
34. **Etheostoma caprodes** (Rafinesque). * † *Log perch.* (R, Cl, CP, St.) Common in Clear Creek and relatively common in the Cumberland.
35. **Etheostoma aspro** (Cope and Jordan). * † *Black-sided darter.* (Cl, R, CB, St.) Not common. Specimens from Clear and Straight creeks were large.
36. **Etheostoma blennioides** Rafinesque. * *Green-sided darter.* (R.) Not common; four fine specimens taken.
37. **Etheostoma zonale** (Cope.) * (R.) Not common.
38. **Etheostoma cœruleum** Storer. * *Rainbow darter.* (R.) Only a few specimens taken.
39. **Etheostoma stigmæum** Jordan. *Speck.* (St.) Very common.
40. **Etheostoma camurum** (Cope). * *Blue-breasted darter.* (R.) One fine large specimen taken.
41. **Etheostoma maculatum** Kirtland. * †
42. **Etheostoma phoxocephalum** Nelson. *
43. **Etheostoma simoterum** (Cope). * †
44. **Etheostoma virgatum** (Jordan). * †

FISHES OF CLINTON COUNTY.

During the spring of 1889 and the autumn of 1890 Prof. Philip H. Kirsch made an interesting collection of fishes from the streams of Clinton County, Kentucky. The writer has been permitted to examine this collection and to make a list of the species in advance of the publication of Prof. Kirsch's report. Several forms, abundant in Clinton County, were not obtained in other parts of the State. A new species of *Etheostoma* is the most common representative in that region of the family to which it belongs. The following list is important as affording the means of comparing the faunas above and below the falls of the Cumberland River. Species marked S are from Smith Creek; those marked Sp, from Spring Creek; A, from Albany Branch; I, from Indian Creek, and P, from a pond near Albany.

1. **Ameiurus nebulosus** (Le Sueur). *Common bullhead.* (Sp.) One specimen taken.
2. **Catostomus nigricans** Le Sueur. *Hog sucker.* (I, A.)
3. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow.* (I.) Not common; specimens all large.
4. **Campostoma anomalum** (Rafinesque). (S, Sp, A, P.) Common; abundant in Smith Creek.
5. **Notropis telescopus** (Cope). (I.) Rare.
6. **Notropis deliciosus** (Girard). (S, A.)
7. **Notropis megalops** (Rafinesque). *Common shiner.* (S, Sp, A, P.) Very common.
8. **Notropis umbratilis cyanocephalus** (Copeland). (S, Sp, A, I, P.) Common. Quite variable; colors very bright.
9. **Notropis galacturus** (Cope). *Milky-tailed shiner.* (S, Sp, A, I.) Especially abundant in Spring Creek. Specimens very fine.
10. **Chrosomus erythrogaster** Raf. *Red-bellied dace.* (S, Sp, A, I.) Common. Colors very bright.
11. **Hybopsis kentuckiensis** (Rafinesque). *Chub; Hornyhead.* (S, Sp, A, P.) Not abundant.
12. **Hybopsis amblops** (Rafinesque). *Silver chub.* (I.) Rare.
13. **Rhinichthys atronasus** (Mitchill). *Black-nosed dace.* (Sp, A, I.) Common. Specimens very variable.
14. **Semotilus atromaculatus** (Mitchill). *Chub; Horned dace.* (Sp, A, P.) Common.
15. **Ambloplites rupestris** (Rafinesque). *Rock bass; Goggle-eye.* (S, Sp, A, I.) Common.
16. **Lepomis megalotis** (Rafinesque). *Long-eared sunfish.* (I.) Only three adult specimens taken.
17. **Etheostoma blennioides** Rafinesque. *Green-sided darter.* (S, Sp, I.) Common; very abundant in Spring Creek. Specimens very large.
18. **Etheostoma flabellare** (Rafinesque). (S, A, I.) Abundant in Albany Branch.
19. **Etheostoma cœruleum** Storer. *Rainbow darter.* (A, I.) Common. Markings peculiar.
20. **Etheostoma, probably rufolineatum.**
21. **Etheostoma** sp. nov. (S, Sp, A, I.) Very abundant. *E. obeyense,* described by Prof. Kirsch in article No. 9, U. S. Fish Commission Bulletin, 1890.
22. **Stizostedion canadense** (C. H. Smith). *Sauger.* One specimen taken.

FISHES COLLECTED BY DR. DAVID S. JORDAN IN WHITLEY COUNTY.

The following is a list of fishes collected by Dr. David S. Jordan, in 1883, in the Clear Fork of the Cumberland River, Wolf Creek, and Briar Creek, near Pleasant View, Whitley County, Kentucky:

1. *Ameiurus natalis* (Le Sueur).
2. *Catostomus teres* (Mitchill).
3. *Catostomus nigricans* Le Sueur.
4. *Moxostoma velatum* (Cope).
5. *Moxostoma duquesnei* (Le Sueur).
6. *Campostoma anomalum* (Rafinesque).
7. *Chrosomus erythrogaster* Rafinesque. Very abundant in small streams.
8. *Pimephales notatus* (Rafinesque).
9. *Ericymba buccata* Cope. Abundant.
10. *Notropis umbratilis cyanocephalus* Copeland. Common.
11. *Notropis megalops* Rafinesque.
12. *Rhinichthys atronasus* (Mitchill). Common in clear cold streams.
13. *Ambloplites rupestris* (Rafinesque).
14. *Lepomis megalotis* (Rafinesque).
15. *Lepomis cyanellus* Rafinesque.
16. *Lepomis macrochirus* Rafinesque.
17. *Micropterus dolomieu* Lacépède.
18. *Etheostoma aspro* (Cope and Jordan).
19. *Etheostoma blennioides* Rafinesque. Taken only in river channel.
20. *Etheostoma susanna* Jordan. (Type.)*
21. *Etheostoma sagitta* Jordan. (Type.)*
22. *Etheostoma cumberlandicum* Jordan. (Type.)*

LOWER TENNESSEE RIVER.

Tennessee River, about 3 miles up the river from Paducah, July 28; water temperature, 82° F. At this place the river is about three-quarters of a mile wide, and the current is very swift except near the large sandbars. Some collecting was done on a very large sandbar, which sloped so gradually that one could easily wade 100 yards from the shore. The bottom is of smooth, fine gravel, covered to a depth of 2 to 4 inches with a fine mud. A few species of minnows were very abundant, especially *Hybognathus nuchalis*. Very few specimens of any kind of food-fish were taken.

FISHES OF THE LOWER TENNESSEE RIVER.

1. **Acipenser rubicundus** Le Sueur. *Shovel-fish; Sturgeon.* Very common in quiet water.
2. **Lepisosteus osseus** (Linnæus). *Common* or *Needle-nosed gar.* Common.
3. **Lepisosteus platystomus** (Rafinesque). *Duck-billed* or *Wide-nosed gar.* Only one specimen taken.
4. **Ictalurus punctatus** (Rafinesque). *Blue, Spotted,* or *Channel cat.* Very abundant. Only small specimens taken.
5. **Carpiodes velifer** (Rafinesque). *Quillback.* Common.
6. **Moxostoma duquesnei** (Le Sueur). *Redhorse.* Reported common, but few specimens were taken.
7. **Hybognathus nuchalis** (Agassiz). *Silvery minnow.* Abundant. Lateral line from 38 to 40.
8. **Notropis whipplei** (Girard). *Blue minnow.* Common.
9. **Notropis atherinoides** Rafinesque. *Rosy minnow.* Common. Three of the largest measure as follows: Length, 62 millimeters, 65, 64; head, 13½, 14, 13½; depth, 12, 12½, 11; eye, 4, 4, 4; lateral line, 46, 46, 48; anal, 11, 11, 11. Back compressed; no distinct vertebral band.
10. **Hybopsis storerianus** (Kirtland). *Spawn-eater.* Common.
11. **Dorosoma cepedianum** (Le Sueur). *Mud shad.* Not very common.
12. **Labidesthes sicculus** Cope. *Brook silverside.* Plentiful.
13. **Etheostoma nigrum** (Rafinesque). *Johnny darter.* Rare.
14. **Etheostoma caprodes** (Rafinesque). *Log perch.* Eight specimens taken.
15. **Stizostedion vitreum** Mitchill. *Jack.* Not common.
16. **Micropterus dolomieu** Lacépède. *Small-mouthed black bass; "Trout."* Common; reported very abundant in several fine lakes near this place.
17. **Aplodinotus grunniens** Rafinesque. *Fresh-water drum; Grunter; White perch.* Common, and much used for food.
18. **Roccus chrysops** (Rafinesque). *White bass.* Quite common.

*For the original descriptions of these species, see Proc. U. S. Nat. Mus., 1883, 249–251.

UPPER TENNESSEE RIVER.

Powell River, 8 miles south of Cumberland Gap, Tennessee, August 16; water temperature, 69° F. Powell River is a fine mountain stream, flowing to the southwest, and parallel with the Cumberland Mountains for 100 miles or more. At the seining station, which was some 25 miles from its mouth, it is about 150 yards wide, with a rock bottom. At intervals there are large banks of sand jutting out into the river, making the landing of the seine comparatively easy. The water is clear, with a swift current; it varied in depth in the channel from 4 to 8 feet, but the stream was somewhat swollen from recent rains. Crayfishes and turtles (*Aromochelys carinatus*, *Aspidonectes spinifer*, *Malaclemmys geographicus*) were abundant, the last named species being very common. A few unios were also taken; *U. plicatus*, *U. gracilis*, and *U. tuberculatus* were most common. No plant life was noticed in the bed of the river. This stream was very much better stocked with fishes than those on the north side of the mountains. Black bass, goggle-eye, sunfishes, and a few species of minnows and darters were common. Among the last mentioned the sand darter was the most abundant.

The stream is an excellent one for the more game or predatory species, and trout, presumably *Salvelinus fontinalis*, "regular spotted brook trout", were reported to have been formerly abundant, but no specimens were observed.

FISHES OF THE UPPER TENNESSEE RIVER.

1. **Lepisosteus osseus** (Linnæus). *Common gar-pike.* Common; several specimens taken.
2. **Ictiobus bubalus** (Rafinesque). *Buffalo.* Not common.
3. **Catostomus nigricans** Le Sueur. *Hog sucker.* Quite common.
4. **Moxostoma duquesnei** (Le Sueur). *Redhorse; Common sucker.* Only very small species taken, but these were quite common.
5. **Campostoma anomalum** (Rafinesque). *Dough-belly.* Not common.
6. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow.* Only about a dozen specimens taken.
7. **Notropis whipplei** (Girard). *Blue minnow.* The most abundant of all the minnows. Specimens large and highly colored.
8. **Notropis dilectus** (Girard). Not common.
9. **Notropis deliciosus** (Girard). Rare; color light.
10. **Notropis megalops** (Rafinesque). *Shiner.* Not common.
11. **Hybopsis amblops** (Rafinesque). *Silver chub.* Comparatively plentiful.
12. **Hybopsis wataugа** Jordan and Evermann. Only a few small specimens taken.
13. **Hybopsis kentuckiensis** (Rafinesque). *Chub; River chub.*
14. **Fundulus catenatus** (Storer). Rare.
15. **Labidesthes sicculus** Cope. *Brook silverside.* Only one specimen taken.
16. **Ambloplites rupestris** (Rafinesque). *Goggle-eye; Rock bass.* Common, not large.
17. **Lepomis megalotis** (Rafinesque). *Long-eared sunfish.* Quite common.
18. **Micropterus dolomieu** Lacépède. *Black or Green bass; "Trout."* Plentiful.
19. **Etheostoma pellucidum** Baird. *Sand darter.* The most common of the darters.
20. **Etheostoma caprodes** (Rafinesque). *Hickory.* Common.
21. **Etheostoma aspro** (Cope and Jordan). *Black-sided darter.* Not common.

MAYFIELD CREEK.

Mayfield Creek at Hickory Grove, July 28; water temperature, 75° F. The collecting station was ½ mile east and ¾ miles south of the railroad station, at "The Old Mill Pond" and "The Basin." Mayfield Creek rises near the southern boundary of the State, in Calloway County. It is about 60 miles long, flows in a northwesterly and then in a westerly direction to the Mississippi River, which it joins in Carlisle County. The place examined is about 20 miles from its source. Here the stream is not more than 20 yards wide. The banks are low and steep, and the bottom is composed of sand and gravel, with a light coat of mud in places. The water, at the time the stream was visited, was very low and turbid, there having been no rain in that locality for eight weeks. Crayfishes were abundant, and a few unios were also found, but there was no plant life of any kind in the bed of the stream. The creek is well provided with a good variety of fishes, but no large food species were obtained, the places fished having recently been seined. The stream is said to be quite well stocked, considering its size. The soil is of a recent geological formation (Quaternary), consisting of a poor white clay mixed with fine sand. The low, level country is densely covered with forest trees, the most common of which are hickory, oaks, ash, sweet gum, and birch, with some cypress, tulip trees, and cherry.

FISHES OF MAYFIELD CREEK.

1. **Ictalurus punctatus** (Rafinesque). *Fork-tailed cat; Blue cat.* Very abundant, but the specimens taken were all small.
2. **Ameiurus nebulosus** (Le Sueur). *Common bullhead.* Not common.
3. **Ameiurus natalis** (Le Sueur). *Yellow cat.* Five specimens taken.
4. **Noturus gyrinus** (Mitchill). The most common variety taken.
5. **Noturus miurus** Jordan. Only three specimens taken.
6. **Catostomus nigricans** Le Sueur. *Spotted* or *Hog sucker.* Rare; one specimen taken.
7. **Catostomus teres** (Mitchill). *Fine-scaled sucker; Brook sucker.* Quite abundant. Lateral line 68, 67, and 71. Although widely distributed and generally very common this is the only place in this part of the country where this species was taken in large numbers.
8. **Carpiodes velifer** (Rafinesque). *Quillback; Bony carp.* One specimen taken.
9. **Moxostoma duquesnei** (Le Sueur). *Common redhorse; White sucker.* By far the most common species of this family.
10. **Erimyzon sucetta** (Lacépède). *Chub sucker.* Common; but not found in other streams in this locality. Lateral line 43, crowded anteriorly; back and shoulders broad and heavy.
11. **Hybognathus nuchalis** (Agassiz). *Silvery minnow.* Very abundant; specimens large; lateral line, 40 or 41.
12. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow.* Common.
13. **Notropis umbratilis cyanocephalus** Copeland. *Redfin.* Common; the only species of this genus taken. The specimens averaged 58 millimeters long; color rather light for this species; spot before the dorsal very pale; lateral line, 46 to 48.
14. **Hybopsis amblops** (Rafinesque). *Silver chub.* Rare; three specimens taken. Plumbeous band on sides pale; lateral line, 38.
15. **Semotilus atromaculatus** (Mitchill). *Creek chub.* Not common. Lateral line, 55.

16. **Opsopœodus emiliæ** Hay. One large specimen taken. Length, 50 millimeters; head, 11; depth, 11; lateral line, 40, little decurved, no very distinct lateral band, no vertebral line nor dark markings on the dorsal. The color of this species seems to be extremely variable. One specimen from New Harmony, Indiana, shows a light lateral band, caused by each scale having a dark edge; lateral line, 38. Another specimen from the same locality shows a well-defined lateral line, with no vertebral line nor black markings on the fins. Length, 38 millimeters; 39 scales. A specimen from Mount Vernon, Indiana, has no dark markings along the lateral line, but has a very dark vertebral band, with first rays of the dorsal and base of anal dusky. Lateral line complete, with 34 scales. Three specimens from Pearl River, Missouri, each 30 millimeters long, have a well-defined lateral band, one scale in width, but no dark markings on fins. Lateral line, 36. Two specimens from the Maumee River, Ohio, the northernmost locality for this species, each 45 millimeters in length, have a very indistinct lateral band, no vertebral line, but a large black spot on the first rays of the dorsal. (See Plate LI, Fig. 1.) Other specimens in the Museum measured:

Length.	Head.	Depth.	Eye.	Lateral line.
39	9	9	3	38
34	8	8+	2.5	40
30	7	7.5	2+	40

17. **Lucius vermiculatus** (Le Sueur). *Pike; Pickerel.* Only two specimens taken.
18. **Notemigonus chrysoleucus** (Mitchill). *Roach.* Quite common. Anal rays, 13, 13, 14, 14.
19. **Zygonectes notatus** (Rafinesque). *Top-minnow.* Quite common. Largest specimen 61 millimeters long.
20. **Labidesthes sicculus** Cope. *Brook silverside.* Only one specimen taken.
21. **Aphredoderus sayanus** (Gilliams). *Pirate perch.* Very abundant. Lateral line, 50.
22. **Centrarchus macropterus** (Lacépède).
23. **Pomoxis annularis** Rafinesque. *Calico bass; Strawberry bass.* Common; several large specimens taken.
24. **Chænobryttus gulosus** (Cuv. & Val.). *War-mouth.* Common; several specimens taken.
25. **Lepomis megalotis** (Rafinesque). *Long-eared sunfish.* Plentiful; the most common species of this family.
26. **Lepomis cyanellus** Rafinesque. *Green sunfish.* Not common; only three specimens taken. Lateral line, 48.
27. **Etheostoma aspro** (Cope and Jordan). *Black-sided darter.* The most common darter at this place. Specimens very large and stout; depth in length (four specimens) 4¼, 5¼, 5¼, and 5⅛. The black blotches on the sides reach well under the belly; lateral lines from 63 to 65.
28. **Etheostoma nigrum** (Rafinesque). *Johnny darter.* Not common; only a few small specimens taken.
29. **Etheostoma phoxocephalum** Nelson. Rare. Specimens small.
30. **Etheostoma fusiforme** (Girard). One specimen taken. Length 30 millimeters; head in length, 3⅗; depth, 3¼; lateral line, 46 (15 pores). Color light, mottled above with brown.

OBION RIVER.

Obion River, near Cypress, July 30; water temperature, 76° F. The examination was made 12 miles northeast of Moscow and about 20 miles from the mouth of the stream. Obion River rises in Graves County, and flows north and then west to the Mississippi River. The stream is narrow and deep and about 65 miles long. It is much larger than the "Bayou", but of very much the same character. The bottom is of mud, from 2 to 4 feet deep, resting on a stratum of quicksand, and it is therefore nearly impossible to wade over it. Numerous springs along the banks of the river keep the mud always soft and miry, so that it is very dangerous for cattle to approach the water. There is but one place in its entire course where gravel is found in the bed of the stream; this is known as the "Gravel Ford", and is at the foot of McLeod's Bluff. The bluff rises to a height of more than 100 feet above the stream, while 30 feet above the water there is a layer of gravel, 18 inches thick, running horizontally through the hill. As the face of the bluff wears away, the gravel drops down and is washed into the water, but does not extend entirely across the stream. The gravel is coarse and well worn. The stream is reported, by those living near it, to contain an abundance of fishes, but, owing to the depth of the mud and the great quantities of drift that are everywhere present, it was impossible to make a satisfactory collection. Turtles (*Malaclemmys geographicus* and *Aspidonectes spinifer*) were common, but no unios were taken.

FISHES OF OBION RIVER.

1. **Lepisosteus osseus** (Linnæus). *Gar; Gar-pike.* Quite common.
2. **Ictalurus punctatus** (Rafinesque). *Spotted* or *Channel cat.* Reported as being common, but very few specimens were taken.
3. **Carpiodes difformis** Cope. *Buffalo sucker.* Common; specimens small.
4. **Carpiodes velifer** (Rafinesque). *Quillback; Bony carp.* Quite common.
5. **Hybognathus nuchalis** (Agassiz). *Silvery minnow.* Very common.
6. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow.* Rare.
7. **Notropis megalops** (Rafinesque). *Common shiner.* Very common.
8. **Notropis deliciosus** (Girard). Common. Specimens without dark markings.
9. **Notropis jejunus** (Forbes). Not common.
10. **Notropis umbratilis cyanocephalus** Copeland. *Redfin.* Not common; much less abundant than in the Bayou de Chien.
11. **Notropis atherinoides** Rafinesque. *Rosy minnow.* But few specimens taken, all small.
12. **Opsopœodus bollmani** Gilbert. Three specimens were taken, two males and one female. This species has been obtained in only two localities, namely: in the Satilla River, Waycross, Georgia, in 1889, by Mr. Charles H. Bollman,* and at this place. The specimens from Obion River agree perfectly with the description of Dr. Gilbert. (See Plate LI, Fig. 2.)

* C. H. Gilbert, see Notes on Fishes from the Lowlands of Georgia, Bull. U. S. Fish Commission, 1888, page 226.

13. **Dorosoma cepedianum** (Le Sueur). *Mud shad; Hickory shad.* Abundant in the sluggish waters of this stream.
14. **Zygonectes notatus** (Rafinesque). *Top-minnow.* Common.
15. **Gambusia patruelis** (Baird and Girard). *Top-minnow.* Plentiful.
16. **Lucius vermiculatus** (Le Sueur). *Pickerel.* Not common.
17. **Labidesthes sicculus** Cope. *Brook silverside.* Only five specimens taken.
18. **Aphredoderus sayanus** (Gilliams). *Pirate perch.* Only one specimen taken. Scales, 46.
19. **Pomoxis annularis** Rafinesque. *Calico bass.* Common.
20. **Pomoxis sparoides** (Lacépède). *Crappie; Calico bass.* Common.
21. **Chænobryttus gulosus** (Cuv. & Val.). *War-mouth.* Plentiful; specimens all small.
22. **Lepomis megalotis** (Rafinesque). *Long-eared sunfish.* Very common.
23. **Lepomis macrochira** (Rafinesque). Several specimens were taken, all smaller than those from the Tradewater River. Length, 30 millimeters.
24. **Micropterus dolomieu** Lacépède. *"Trout."* Common.
25. **Micropterus salmoides** (Lacépède). *Big-mouthed trout.* Less common than *M. dolomieu.*
26. **Etheostoma shumardi** (Girard). Not common.
27. **Etheostoma caprodes** (Rafinesque). *Log perch.* Rare.
28. **Etheostoma aspro** (Cope and Jordan). *Black-sided darter.* Only three small specimens taken.
29. **Etheostoma ouachitæ** Jordan and Gilbert (?). One specimen, too small to be positively identified.
30. **Aplodinotus grunniens** (Rafinesque). *White perch; Drum.* A common and much valued food-fish.

BAYOU DE CHIEN.

Bayou de Chien, near Moscow, July 29; water temperature, 68° F. One collecting station was just north of Moscow, and another about 3 miles west of that place. Bayou de Chien is a large, sluggish stream, rising in the southern part of Graves County, and flowing in a westerly direction for about 20 miles, to the Mississippi River. Moscow is about midway of its course, and it is there about 15 yards wide, with low, precipitous banks. The stream is very crooked, and is almost filled with logs, brush, and roots. The bottom consists of a fine soft mud, varying from a few inches to a few feet in depth. No vegetable life whatever was found growing in it. The low temperature of the water can be accounted for by the facts that the stream flows for nearly its entire length through woods and that it is fed chiefly by cold springs. The depth of the water varies from 3 to 5 feet between the ripples. On either side of the stream, from a quarter to a half mile, the country is very low, overflowing in the winter and spring with back water from the Mississippi River. This tract is covered with a dense growth of oaks, hickories, cypress, and water-birch. Its soil is a hard white clay, unfit for cultivation. Beyond this strip of lowland the country is undulating and has a rich soil, well adapted to agriculture, and producing fine crops of corn, wheat, clover, tobacco, and, formerly, cotton.

The stream is well stocked with fishes, but is much better adapted to the more sluggish varieties, such as suckers, carp, catfish, etc. Sunfishes were also found in abundance; black bass were plentiful but they lacked the alertness and activity of those living in clear swift streams. I wish to acknowledge my indebtedness to the citizens of Moscow for their kindness and assistance while working there.

FISHES OF THE BAYOU DE CHIEN.

1. **Amia calva** Linnæus. *Dogfish; Grinnel.* Reported to be very abundant. No ... obtained, but a very large one was seen that had been taken by ... to take a minnow the same as a bass and to be equally difficult to ... water and fighting vigorously for several minutes; frequently ... pounds, and furnishes much sport for the angler, but is seldom used ...
2. **Lepisosteus platystomus** (Rafinesque). *Gar.* Quite common, and said to ... other fish.
3. **Ictalurus punctatus** (Rafinesque). *Channel* or *Spotted cat.* Not common. ... were reported to be especially abundant during the spring months, ... year much difficulty was experienced in finding specimens.
4. **Ameiurus nebulosus** (Le Sueur). *Bullhead.* But few specimens ...
5. **Noturus gyrinus** (Mitchill). Not common.
6. **Ictiobus bubalus** (Rafinesque). *Buffalo; Small-mouthed buffalo.* ...
7. **Moxostoma duquesnei** (Le Sueur). *Redhorse; White sucker.* Not ...
8. **Hybognathus nuchalis** (Agassiz). *Silvery minnow.* Very abundant ... Anal rays, 7.
9. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow.* Rare.
10. **Notropis whipplei** (Girard). *Blue minnow.* One specimen taken.
11. **Notropis atherinoides** Rafinesque. *Rosy minnow.* Not abundant ... in length, 4.8; eye, 3 in head; back compressed; color ...
12. **Hybopsis storerianus** (Kirtland). *Spawn-eater.* Quite common ... lateral line, 41 to 44.
13. **Opsopœodus emiliæ** Hay. One large specimen taken. Length ... 3; a faint lateral band; dorsal with a small black spot ...
14. **Dorosoma cepedianum** (Le Sueur). *Hickory shad; Gizzard ...* region swarm with this species, especially the bayous ...
15. **Zygonectes notatus** (Rafinesque). *Top-minnow.* Not ... species; but few taken.
16. **Lucius vermiculatus** (Le Sueur). *Pike; Pickerel.* ...
17. **Labidesthes sicculus** Cope. *Brook silverside.* Rare; ...
18. **Anguilla chrysypa** Rafinesque. *Eel.* Reported very ...
19. **Aphredoderus sayanus** (Gilliams). *Pirate perch.* Common ...
20. **Notemigonus chrysoleucus** (Mitchill). Very abundant ...
21. **Chænobryttus gulosus** (Cuv. & Val.). *Big-mouthed ...*
22. **Pomoxis annularis** Rafinesque. *Crappie.* Common ...
23. **Pomoxis sparoides** (Lacépède). *Calico bass.* Quite ...
24. **Lepomis megalotis** (Rafinesque). *Common sunfish.* ...
25. **Lepomis pallidus** (Mitchill). *Blue sunfish.* Abundant ... indistinct.
26. **Lepomis garmani** Forbes. Only one specimen ...
27. **Lepomis heros** (Baird and Girard). Only ...
28. **Micropterus dolomieu** Lacépède. *Trout; J...*
29. **Micropterus salmoides** (Lacépède). *Bla...*
30. **Etheostoma nigrum** (Rafinesque). *Johnny da...* of the stream, but variable.
31. **Etheostoma caprodes** (Rafinesque). *Log...*
32. **Etheostoma aspro** (Cope and Jordan). *Bl...*
33. **Etheostoma fusiforme** (Girard). Only one ...
34. **Aplodinotus grunniens** Rafinesque. *Whee...* mon; and extensively used for food.

UPPER KENTUCKY RIVER.

The Upper Kentucky River is formed by the union of three streams, namely: the South, Middle, and North Forks, and their tributaries. These branches all rise on the northern slope of the Pine Mountains, flow in a northwesterly direction, and unite in Lee County. The country is mountainous throughout. The steep hills are composed chiefly of sandstone, and contain great quantities of coal; veins from a few inches to a few feet in thickness can be seen everywhere along the streams and mountain sides. The slopes of the mountains are covered with a heavy growth of timber; small yellow pine, beech, maple, oak, walnut, birch, and tulip tree are the most common. Among the shrubs are the cucumber (*Magnolia macrophylla*), dogwood, papaw, wild plum, and two or three species of hawthorns; while water birch, sycamore, elm, and cottonwood grow along the streams. Collections were made in Clay, Leslie, Perry, and Knott counties.

THE SOUTH FORK.

1. *Horse Creek*, Garratsville, August 20; water temperature, 72° F. Horse Creek is a long, narrow stream, tributary to Goose Creek, in which collections were made about 2 miles from its mouth. At the collecting station the stream is only about 25 feet wide, shallow, and with but little current. It is composed of a series of short ponds, varying from 2 to 4 feet in depth, and connected by shallow ripples. The bottom is of sand and mud, the banks are low and steep, and the water is overhung with willows, sedges, and grasses. The station was not a good one for collecting, and but few species of fishes were taken.

2. *Goose Creek*, Garratsville, August 20; water temperature, 70° F. Goose Creek is the largest western tributary of South Fork, and flows almost parallel with that river for 40 miles. At the point visited, which is about 15 miles from its mouth, the stream is from 15 to 20 yards wide. The bottom consists of shale and slate, with mud and sand in places. The ripples are short, swift, and rough. No plant life was discovered in the stream; no unios and only a few crayfishes and smaller crustaceans were taken. The creek was well stocked with fishes; suckers (*Moxostoma duquesnei* and *Catostomus nigricans*) being especially abundant.

3. *Hector Creek*, 5 miles west of Big Creek post-office; water temperature, 73° F. Hector Creek is a southern tributary of South Fork, or Redbird, as its upper course is called. The creek is narrow and rocky, nowhere reaching a width of more than 25 feet or a depth of more than 4 feet. The bottom consists either of smooth flat rock or of broken stones and gravel. The stream, small as it is, contains an abundance of small fishes, and in no place were the commoner species more plentiful. *Campostoma anomalum*, *Ericymba buccata*, *Catostomus nigricans*, two or three species of *Notropis*, and *Pimephales notatus* were especially abundant. Darters were also quite common, and some fine specimens of *Etheostoma spilotum* were taken, these being the second specimens that have been found.

4. *Redbird Creek* (South Fork), 1 mile west of Big Creek, August 22; water temperature 75° F. Collections were made at the crossing of the London road, and also about a mile farther down the stream. At the crossing there is a very long, shallow ripple, where most of the collecting was done. Redbird Creek is 75 or 80 miles long.

It is 35 or 40 yards wide at this station, which is 35 miles from its source. The bottom consists of rock, and the average depth of water is from 3 to 5 feet, with occasional deeper places, which generally have a muddy bottom. Several very large smooth sandbars were noticed, but they were not common. The ripples are shallow and smooth enough to make seining easy. The stream is well stocked with fishes, 28 species having been obtained. The commoner varieties of food-fishes were abundant. Darters were quite numerous on the ripples, especially *E. variatum*, a rare species in other localities. Ten specimens of *E. spilotum* were also taken, and *E. pellucidum* was common on the sandbars. The favorite method of fishing here is by means of the spear at night with the aid of a torch, while the fish are spawning in the shallow waters.

5. *Big Creek*, at Big Creek post-office, August 22; water temperature, 74° F. Big Creek is a small eastern tributary of Redbird, shallow and very rocky. For its entire length, about 15 miles, the bottom of the stream is one continuous bed of stones, containing no plant life and but few fishes. Collections were made one mile from the mouth of the stream. Very few specimens were obtained, *Notropis megalops* and *Catostomus nigricans* being about the only species that were common.

THE MIDDLE FORK.

6. *Bull Creek*, 4 miles west of Hyden, August 23; the water temperature was 68° F. This is a small western tributary of Middle Fork, about the same size as Big Creek, but of a different character. It is narrower and deeper and less rapid and stony. The bottom is of slate and stone, with short interspaces of gravel. Collections were made at the crossing of the Hazard road. The creek contains an abundance of small fishes, 18 species having been taken from the stream and from a small bayou. The bayou contained great numbers of minnows, *Cliola vigilax*, *Pimephales notatus*, and *Campostoma anomalum*.

7. *Middle Fork*, August 23; water temperature, 70° F. The collecting station was 4 miles north of Hyden and three-quarters of a mile below the crossing of the Hazard road. Middle Fork is larger and deeper than Redbird, with less frequent ripples. At the seining station, about 40 miles from its mouth, the stream is 50 yards wide and very swift on the ripples. The ripple where the collecting was done is about half a mile long, and the upper part has a smooth stone bottom, thickly strewn with large loose stones. The entire bed of the stream and surface of the stones, where covered with water, are thickly overgrown with a species of *Potamageton*. Hiding among these weeds were great numbers of small catfishes (*Noturus miurus*), small darters (*Etheostoma zonale*), and the young of *E. flabellare*. Several hundred specimens of the catfish and of *E. zonale* were taken in a few hauls of the seine. Nearer the middle of the ripple the bottom was composed of coarse gravel and broken stones, the weeds growing there only in small isolated bunches. Here the most common species obtained were black bass, minnows (especially *Notropis whipplei*), and darters (*E. aspro*, *E. variatum*, *E. spilotum*, and a few *E. nigrum* and *blennioides*). The gravel next gave way to a smooth sand bottom with deeper water, where *E. pellucidum* was taken in abundance, and several species of *Notropis*, especially *N. argo* and other soft-rayed fishes, were common. Twenty-nine species in all were obtained. The stream is an excellent one for many varieties of food-fishes, but fishing is reported to be carried on extensively by means of seines and spears, and also by the use of dynamite.

8. *Cutshin Creek*, August 24; water temperature, 68° F. The collecting station was 4 miles east of Hyden and 3 miles from the point where this creek flows into the Middle Fork. Cutshin Creek is probably the largest eastern tributary of the Middle Fork, and is 25 or 30 miles long. The stream is rocky and swift, but quite deep in places; the bottom is of rock, with low steep banks and with frequent sandbars. The ripples are broad and shallow and devoid of vegetation. The stream is well stocked with fishes. Black bass (*M. dolomieu*), minnows, and darters are common, the bass being especially abundant, and *Etheostoma spilotum* and *E. variatum* were also obtained. Twenty species in all were taken.

THE NORTH FORK.

9. *North Fork*, just south of Hazard, August 25; water temperature, 76° F. North Fork is the largest of the three rivers that unite to form the Kentucky. It is more open than either the South Fork or the Middle Fork, the valley being wider and the bed more sandy. It also contains many long sandbars and stretches of mud bottom. The water is clear and has considerable current. Crawfishes were more numerous than in the other streams, and unios were abundant, the most common species being *U. multiplicatus*, *U. ligamentinus*, and *U. anodontoides*. Fishes were not so plentiful as in the South and Middle Forks, nor were so many species taken. The station was not a good one for obtaining darters, as the ripple was full of rocks. Catfishes (*Ictalurus punctatus*) and suckers (*Moxostoma duquesnei*) were secured in large quantities by means of traps and trot lines. The writer was indebted to Mrs. Elhannen Combs, of Hazard, Kentucky, for assistance between Hazard and Pikeville.

10. *Lot Creek*, Hazard, August 26; water temperature, 74° F. This creek was examined 2 miles west of Hazard and 1 mile from its mouth. Lot Creek is a small eastern tributary of the North Fork, about 15 miles long and from 6 to 8 yards wide. The banks are low and steep, the bed is of sand and mud, with very little rock exposed. The stream is composed of a series of ponds, from 2 to 4 feet in depth, connected by short ripples running over fine gravel. The valley through which it flows is of loose soil; it is from a quarter to half a mile wide; willows, elms, and water birch overhang the stream. Bass, goggle-eyes, and sunfishes were very abundant; minnows, suckers, and darters were plentiful. The total number of species obtained was 21.

11. *Troublesome Creek*, Dwarf, August 27; water temperature, 76° F. The collecting station was at the crossing of the Hazard and Hindman road, 12 miles northeast of Hazard and 9 miles west of Hindman. Troublesome Creek, the largest eastern tributary of the North Fork, rises in the eastern part of Knott County and flows northwest for more than 100 miles before joining the North Fork. The stream is swift and rocky, with an occasional sandbank. There are numerous deeper places, the bottoms of which are covered with large sandstones. The water is clear, cool, and devoid of plant life, except a few scattered bunches of water moss (*Fontinalis*). Collecting was restricted entirely to the ripples on account of the great number of stones in the deeper water. Bass, sunfish, and darters were the most common species.

12. *Left Troublesome Creek*, at Hindman, August 28; water temperature, 68° F. This is a small stream with a sandy bottom, low sloping shores, and shallow water. But very few species of fishes were taken, *Pimephales notatus*, *Ericymba buccata*, and *Notropis deliciosus* being the most common. The darters were represented by only three species, the most abundant being *Etheostoma cæruleum*.

FISHES OF THE UPPER KENTUCKY RIVER.

1. **Lepisosteus osseus** (Linnæus). *Common gar.* Horse, Big, Lot, and Troublesome creeks. Nowhere abundant in the Upper Kentucky, four being the greatest number taken at any one station.
2. **Ictalurus punctatus** (Rafinesque). *Spotted, Blue,* or *Channel cat.* North Fork. The most widely distributed species of this family; reported from every stream, but scarce at this season of the year.
3. **Noturus miurus** Jordan. Several of this species were taken in Horse Creek, but it was abundant only in Middle Fork. Specimens dark, almost black above, shading to light below.
4. **Carpiodes velifer** (Rafinesque). *Quillback.* Redbird, Middle Fork, and North Fork. Plentiful in the North Fork, the only stream in which it was found abundant. Only young specimens were taken, and these came from shallow water, over sandbars.
5. **Catostomus teres** (Mitchill). *Fine-scaled* or *Brook sucker.* Hector, Goose, and Bull creeks. Nowhere common. Scales much crowded in front, with a black spot on the side under dorsal and before caudal; scales in lateral line, 71.
6. **Catostomus nigricans** Le Sueur. *Hog sucker.* Abundant at every station except Goose Creek. Specimens with little variation, except in color, throughout the river system.
7. **Moxostoma duquesnei** (Le Sueur). *Common sucker.* Taken at every station, except in Hector Creek and Left Troublesome Creek. Horse Creek and Cutshin Creek were abundantly stocked with this species, and large specimens were obtained in both.
8. **Campostoma anomalum** (Rafinesque). *Dough-belly; Stone-lugger.* Common at every station except the first, where it was not taken. This species seems to prefer small and shallow streams, such as Hector Creek, where it was obtained in great numbers, but it was not so common in Redbird Creek or in Middle and North Forks.
9. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow.* Obtained at every station. This species was also more abundant in the smaller streams. In an offshoot of Bull Creek some very large specimens were taken; the largest measured 80 millimeters long, and was very dark in color; lateral band especially broad and dark, passing over opercle and around snout; scales in the lateral line, 40.
10. **Notropis deliciosus** (Girard). Bull Creek, Middle Fork, Cutshin Creek, North Fork, and Troublesome Creek. Found principally in the larger streams, such as Redbird Creek, Middle and North Forks; never largely taken in small streams. This species was generally much more common here than in the western part of the State, especially than in the Green River system. Compared with specimens from other parts of the State and the Mississippi Valley, there is but little variation; the principal difference is in color and in the relative size of the eye. Eight specimens from the North Fork measure as follows:

Length.	Head.	Depth.	Eye.	Lateral line.
52	13—	11—	4	36
49	12—	11	4—	36
49	12	10	4	36
49	12	10	4	33
47	11+	9	4	35
47	11⅓	9⅓	4	35
45	10	8⅔	4—	35
46	10+	8⅔	4—	35

11. **Notropis whipplei** (Girard). *Blue minnow.* Found at every station, but evidently preferring large streams and clear running water.
12. **Notropis megalops** (Rafinesque). *Common silverside, shiner.* Taken at every station except the first, and very abundant in a few streams. Especially common in Big Creek, where the many variations due to age were very evident.
13. **Notropis ariommus** (Cope). Redbird Creek and Middle Fork. Taken at only these two stations; not common at either. Three specimens from Redbird measure as follows: Length, 64, 60, 55; head, 17, 16½, 14; depth, 14, 13½, 11; eye, 6½, 6½, 6; lateral line, 40, 38, 40.

14. **Notropis umbratilis cyanocephalus** Copeland. *Redfin.* Redbird and Bull Creeks. Although this is one of the most variable species of the genus, throughout this region the specimens obtained were all well defined, and when compared with specimens from other parts of the State they showed no constant differences.
15. **Notropis spectrunculus** (Cope?). Redbird. This identification is not positive; the only specimen is more slender and its mouth more terminal than in *N. deliciosus.* There is also a dark caudal spot.
16. **Notropis dilectus** (Girard). Redbird, Bull, and Cutshin creeks, North Fork, Lot, Troublesome, and Left Troublesome creeks. A very widely distributed and comparatively common little minnow, found in the clear running water of both large and small streams. Compared with specimens from other localities within the State, the color is about the only point of difference. Ten specimens from Redbird measure as follows (in millimeters):

Length.	Head.	Depth.	Eye.	Lateral line.
66	13	10+	4	41
60	12	9	3.5	41
62	12.5	10	4—	41
59	11.5	9	3.5	41
61	12	8.5	4—	40
58.5	11.5	9	3.5	41
58.5	11.5	8.5	3.5	40
57	11	8.5	3.5	41
65	12—	9	3.5	41
56	11—	8	3.5	41

17. **Notropis atherinoides** Rafinesque. *Rosy minnow.* Not common.
18. **Notropis arge** (Cope). Horse Creek, Redbird, and North Fork. Not common, but not so rare as the preceding. Four specimens from Middle Fork measured as follows:

Length.	Head.	Depth.	Eye.	Anal.	Lateral line.
93	21	16	7	11	42
93	21	16	7	11	41
81	19	14	6	11	42
82	19	15	6	11	41

One specimen from Redbird measures, 90; 20.5; 15.5; 6.5; 11; 42. Those from Redbird were smaller, but with the same markings, and the same heavy back and shoulders:

Length.	Head.	Depth.	Eye.	Anal.	Lateral line.
74.5	18	13	5	11	43
77	18.5	13	5.5	11	42
74	17	12	5	11	41
79	18	12	5.75	11	41
78.5	18	13	5	11	43
75	17.5	11.5	5.5	11	42

19. **Ericymba buccata** (Cope). Taken at every station. Much more plentiful in the eastern than the western part of the State, and more abundant in the tributaries of the North Fork than in those of the Middle Fork.
20. **Hybopsis amblops** (Rafinesque). *Silver chub.* Obtained at all stations except in Horse, Big, and Bull creeks. Widely distributed, but nowhere very abundant.
21. **Hybopsis kentuckiensis** (Rafinesque). *Chub.* Taken at all stations except in Goose and Left Troublesome creeks. Not abundant at any place, but rather common in Redbird and Big creeks, Middle Fork, and North Fork.
22. **Hybopsis watauga** Jordan and Evermann. Redbird. Very rare.

23. **Semotilus atromaculatus** (Mitchill). *Chub; Horned dace.* Goose, Redbird, and Left Troublesome creeks. Abundant in an old bayou of Bull Creek, but rare at other places. Lateral line from 52 to 56.

24. **Labidesthes sicculus** Cope. *Brook silverside.* Horse and Goose creeks, Redbird and Big Creek. Neither very generally distributed nor plentiful where taken.

25. **Ambloplites rupestris** (Rafinesque). *Rock bass; Goggle-eye.* Goose Creek, Redbird, Big Creek, and Middle Fork. Not common in any stream except Lot Creek.

26. **Lepomis megalotis** (Rafinesque). *Long-eared sunfish.* Taken at every station and abundant in Troublesome Creek. This is the only species of *Lepomis* found in these mountain streams.

27. **Micropterus dolomieu** Lacépède. *Small-mouthed black bass.* Taken at every station, and generally quite common.

28. **Micropterus salmoides** (Lacépède). *Large-mouthed black bass.* Goose Creek, Redbird, Bull Creek, Middle Fork, and North Fork. Neither so widely distributed nor so common as *M. dolomieu*, and preferring more quiet water.

29. **Etheostoma pellucidum** Baird. *Sand darter.* Found most frequently in the larger streams, and most abundant on the sandbars of Redbird.

30. **Etheostoma nigrum** (Rafinesque). *Johnny darter.* Widely distributed; taken in every stream except Goose Creek, but common only in Horse Creek and Redbird. Specimens all small.

31. **Etheostoma blennioides** Rafinesque. *Green-sided darter.* Horse and Goose creeks, Redbird, Big Creek, Middle Fork, Cutshin, Lot, and Troublesome creeks. More common than *E. nigrum*, and larger and finer specimens were obtained.

32. **Etheostoma variatum** (Kirtland). Redbird, Middle Fork, Cutshin and Troublesome creeks. A very handsome darter taken at only a few places, but found in great quantities at some of them. At Redbird about 100 specimens were obtained from the long, gentle ripple at the crossing of the Hazard road. This species is not generally distributed, nor had it been taken previously in large numbers. It has been recorded only from a tributary of the Little Miami (Ohio), Brookville (Indiana), and the falls of the Ohio River at Jeffersonville (Indiana). Six of the largest specimens measured as follows:

Length.	Head.	Depth.	Lateral line.	Dorsal.	Anal.
62	13½	7	58	XIII-13	II-7
65	14	8	56	XIII-12	
63	13½	7	57	XIV-12	
60	13+	7—	59	XIII-13	
58	13	7—	55	XIII-11	
57	13	6.5	58	XIV-12	

33. **Etheostoma spilotum** (Gilbert). Hector Creek, Redbird, Big Creek, Middle Fork, Cutshin, Lot, and Troublesome creeks. This species (or variety of *E. nianguæ*) has never been taken except from the waters of the Kentucky River. It was first obtained by Dr. Gilbert in Sturgeon Creek, Owsley County, Ky., in 1889. We did not find it common at any station, six specimens from the Redbird being the greatest number from any one place. Two of the largest specimens measure as follows: Length, 71, 80; head, 21, 23; depth, 13, 16; eye, 4, 4; lateral line, 58, 59; dorsal, XI-13, XI-13; anal, II-10, II-11. (See Plate LI, Fig. 3.) For a detailed description reference should be made to Proc. U. S. Nat. Mus. 1887, 53.

34. **Etheostoma simoterum** (Cope). Redbird, Bull Creek, Middle Fork, Troublesome Creek. Not common.

Length.	Head.	Depth.	Lateral line.	Dorsal.	Anal.
45	11	10.5	51	X-11	II-7
45	11	10.5	52	XI-11	II-7
45	11	10.5	54	XI-11	II-7
40	10	9	53	XI-11	II-7
40	10	9	50	XI-11	II-7

35. **Etheostoma aspro** (Cope and Jordan). *Black-sided darter.* Goose and Big creeks, Middle Fork, and Troublesome Creek, very rare; only one specimen taken in each of the three streams first mentioned.

36. **Etheostoma zonale** (Cope). Taken in every stream except Hector, Troublesome, and Left Troublesome creeks, and very abundant in several of them. About 280 specimens were taken in one ripple of Middle Fork. Generally common wherever found.

37. **Etheostoma flabellare** (Rafinesque). Goose and Hector creeks, Redbird, Middle Fork, Cutshin, Troublesome, and Left Troublesome creeks. Abundant only in Middle Fork, where 25 or 30 young specimens were taken.

38. **Etheostoma cœruleum** (Storer). *Rainbow darter.* Taken in all the streams except Horse and Goose creeks. Common where found.

BIG SANDY RIVER.

Eight miles east of Hindman, beyond the ridge that divides the Kentucky River system from that of the Big Sandy, a difference in the character of the country and of the streams is quite noticeable. The valleys grow wider, giving room for good farm lands between the hills. The soil produces good crops of corn and vegetables. Pastures of timothy and clover, which were not seen throughout the mountainous part of Kentucky, were here quite common. Fruits, apples especially, do well; many very large trees, apparently of great age, being still in bearing condition. The headwaters of the streams have much the same character as those of the Kentucky River, being rocky and swift; but as the valley widens the sand increases in the bed of the streams and the alluvial banks grow higher. Throughout their lower courses the water is less rapid and forms deeper ponds or pools.

1. *Right Fork of Beaver Creek*, Lackey, August 29; water temperature, 68° F. Beaver Creek is one of the largest western tributaries of the West or (Levisa) Fork of the Big Sandy River. It is about 75 or 80 miles long, and is navigable for 10 or more miles. Lackey is near the middle of its course, and at that place the stream is 30 or more yards in width, with an average depth between the ripples of about 4 feet. The course of the stream is interrupted by frequent ripples, having a depth of only a few inches. The bed is of sand, with rock or mud at intervals. A few crayfishes were taken, but no water plants, except mint, were found in the stream. The creek was well stocked with fishes, the soft-rayed species being most abundant. Suckers (*Moxostoma duquesnei*), sunfish, and bass were the most common food species. The suckers were especially abundant, and minnows and darters were also common.

2. *Shelby Creek*, Robinson, August 30; water temperature, 70° F. Shelby Creek is a small tributary of Robinson Creek, about 6 miles long, and is shallow and rocky throughout its entire length, except for about half a mile in its lower course, where the bed is of sand. Collections were made near its mouth.

3. *Robinson Creek*, Robinson, August 30; water temperature, 68° F. Robinson Creek is a stream of considerable importance, being about 40 miles long and 25 or 30 yards wide, with a depth of 2 to 5 feet at the place where it was visited. The bed is of rock and sand, the former occurring most frequently. The valley of the stream is narrow and the current quite swift. Collections were made at the mouth of Shelby Creek, on a long, deep ripple. Twenty-one species in all were obtained. Quillback (*Carpiodes velifer*), two or three species of *Notropis*, and *Etheostoma variatum* were quite common.

4. *Island Creek*, Pikeville, September 1; water temperature, 69° F. The collecting station was 2 miles east of Pikeville and 1 mile from the mouth of the creek. Island Creek is a small southern tributary of the Levisa Fork of the Big Sandy River, and is only a few miles long. The creek consists of a number of pools, connected by gravelly ripples. Nineteen species of fishes were obtained, minnows and suckers being most abundant.

5. *Levisa Fork of the Big Sandy River*, Pikeville, September 2; water temperature, 72° F. The river at Pikeville is broad and shallow, and yet with sufficient depth to be navigable for small boats during low water. The bed, except at the ripples, which are not numerous, is of light, fine sand, constantly changing its position, and forming large sandbars at intervals. There are long stretches of deep water, but these are the exception, and in such places the bottom is covered with large sandstones. The bottom of the ripples is of stone, on which grow species of *Potamogeton*, both the submerged and floating kinds, but in no great quantities. The stream was seined at the town, but the station was not a good one, and only nineteen species were obtained. A great many fish were brought to town by fishermen, *Ictalurus punctatus*, *Carpiodes velifer*, and *C. carpio* being the most common. Our stay in Pikeville was made pleasant and the work more effective by the kindness and help received from Mr. Parsons and Mr. Conally, of that place.

6. *John Creek*, Zebulon, September 5; water temperature, 69°. John Creek, the largest eastern tributary of the Levisa Fork, is about 80 miles long, and at the place visited, which is only about 20 miles from its source, it is 20 or 25 yards wide, crooked, very rocky, and swift. The greater part of the stream is composed of ripples, which are separated by short ponds with sandy bottoms. Darters (*Etheostoma cœruleum*, *E. blennioides*, *E. zonale*) were common, while among the minnows *Notropis whipplei*, *Ericymba buccata*, and *Hybopsis kentuckiensis* were the most abundant.

7. *Coon Creek*, Zebulon, September 5; water temperature, 71° F. This small tributary of John Creek has a sandy bottom, not reaching bed rock at any place. From it were taken 15 species of fishes, *Lepomis megalotis* and *Ericymba buccata* being quite common.

8. *Blaine Creek*, Catalpa, September 8; water temperature, 73° F. The collecting station was 2 miles west of the railroad bridge. Blaine Creek has about the same length and width as John Creek, but is quite different in character, being very sandy, no rocks appearing at any place in its lower course. The stream seems to be almost devoid of animal and vegetable life, and only a very few fishes were secured. Spring Creek, a small muddy tributary of Blaine Creek, was fished, but only a few minnows were found in it.

In the following list the different streams are designated by letters, as follows: Beaver Creek by Bea; Robinson Creek by R; Shelby Creek by S; Island Creek by I; Levisa Fork of the Big Sandy River by L; John Creek by J; Coon Creek by C; Blaine Creek by B. Some seining was done near the mouth of the Big Sandy River in September, 1888, by Dr. C. H. Gilbert and Dr. James A. Henshall. Species that were taken by them are included in the list, and are indicated by an asterisk (*).

FISHES OF THE BIG SANDY RIVER.

1. **Noturus miurus** Jordan. (B.) One small specimen was obtained. It had the usual markings across the back, but with the rest of the body covered with small black spots; upper third of dorsal black.
2. **Carpiodes velifer** (Rafinesque). *Quillback.* (R, L, J, C.) Common wherever taken; most abundant in the Big Sandy.
3. **Carpiodes difformis** (Cope). *Carp sucker.*
4. **Catostomus nigricans** Le Sueur. *Hog sucker.* (Bea, R, S, I, L, C, B.) Quite common in Island, Coon, and Blaine creeks; most abundant in Island Creek, the specimens from which place were somewhat lighter in color than the average. Lateral line, 47, 49, 46, 45, 47, 46, 46.
5. **Moxostoma duquesnei** (Le Sueur). *Redhorse.* (Bea, R, I, L, C, B*.) Common, except in Coon and Blaine creeks. Lateral line, 41.
6. **Campostoma anomalum** (Rafinesque). *Dough-belly.* (Bea, R, S, I, L, J, C*.) Rare except in Island and John Creeks, preferring clear streams with pebbly bottoms. Lateral line, 47, 48, 50.
7. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow.* Taken at every station in this basin. Rare only in Robinson Creek.
8. **Cliola vigilax** (Baird and Girard). *Bull-headed minnow.* (B.) Taken at only one station; very rare. Lateral line, 43.
9. **Hybognathus nuchalis** (Agassiz).* *Silvery minnow.*
10. **Notropis deliciosus** (Girard). (Bea, I, L, J, C.) Common, except in Levisa Fork. Five of the largest specimens from Island Creek measure as follows:

Length.	Head.	Depth.	Eye.	Lateral line.	Scales before dorsal.
49	12	10	4	36	14
48	12--	9.5	4—	34	14
45	10	10	3	36	13
45	10	9.5	3	36	13
44	10	9	3	36	13

Compared with specimens from the more sluggish streams of Kentucky and other States these are more slender; the caudal peduncle especially is less deep; the lateral band is distinct from the dorsal to the caudal; vertebral line well marked. Specimens from John Creek have a dark spot before caudal and dorsal. Scales before dorsal, 13, 15, 14, 15.

11. **Notropis whipplei** (Girard). *Blue minnow.* Common at every station; the only minnow that was abundant in Blaine Creek.
12. **Notropis megalops** (Rafinesque). *Common shiner.* Taken at every station, but not common in the Big Sandy River or Blaine Creek. Lateral line, 40 to 48.
13. **Notropis ariommus** (Cope). (L.) Rare. Eye 2.5 in head; lateral line, 34.
14. **Notropis dilectus** (Girard). (Bea, R, S, I, L, J, B.*) Rare only in the Big Sandy River and Blaine Creek. Specimens from Island Creek are even darker than those from the Green River system, and are more slender from the dorsal to the caudal. Six specimens measure:

Length.	Head.	Depth.	Eye.	Lateral line.	Head in length.	Depth in length.	Eye in head.
51	12+	10.5	4—	39	4.25	4.85	3
53	13	11	4—	38	4.46	4.81	3.25
55	13	12	4	38	4.22	4.85	3.25
54	12.5	12	4	39	4.15	4.5	3.25
54	12.5	11.5	4	40	4.32	4.6	3.12
55	13	12	4	40	4.38	4.85	3.12

Specimens from the Big Sandy River much lighter in color. Those from John Creek were large, from 61 to 62 millimeters long, but with all the true characters of the species.

15. **Notropis coccogenis** (Cope). (R.) Rare. Length, 74; head, 17†; depth, 15; lateral line, 41; scales before dorsal, 19; teeth, 2, 4–4, 2.
16. **Notropis jejunus** (Forbes).*
17. **Notropis atherinoides** Rafinesque. *Rosy minnow.* (L, J, B.*) One specimen from Blaine Creek and several from the Big Sandy River and John Creek. All have the short snout and compressed back. Vertebral line not distinct; lateral line, 40; 17 scales before dorsal.
18. **Hybopsis amblops** (Rafinesque). *Silver chub.* (Bea, R, L, I, J.) Not abundant; common in Robinson and John creeks. Length, from 37 to 39 millimeters; lateral line, 38, 37, 37, 36. 36; 12 scales before dorsal.
19. **Hybopsis hyostomus** Gilbert. (B.) Rare.
20. **Hybopsis kentuckiensis** (Rafinesque). *Chub; Hornyhead.* (Bea, R, I, L, J, C.) Not plentiful; few specimens taken at any station.
21. **Semotilus atromaculatus** (Mitchill). *Creek chub.* (B.) Not common.
22. **Dorosoma cepedianum** (Le Sueur).* *Mud shad.*
23. **Ericymba buccata** Cope. Taken at every station, and quite common in Big Sandy River and Blaine Creek.
24. **Labidesthes sicculus** Cope. *Brook silverside.* (R, L.) Not common.
25. **Ambloplites rupestris** (Rafinesque). *Goggle-eye; Rock bass.* (B.) Common in the deeper and more quiet places.
26. **Lepomis megalotis** (Rafinesque). *Long-eared sunfish.* Taken at every station, and the only sunfish that was common.
27. **Lepomis pallidus** (Mitchill). *Blue sunfish.* (I.) Rare. Specimens young.
28. **Lepomis cyanellus** Rafinesque. *Green sunfish.* (B.) Only one specimen taken.
29. **Micropterus dolomieu** Lacépède. *Small-mouthed black bass.* Common at every station.
30. **Micropterus salmoides** (Lacépède). *Large-mouthed black bass.* (Bea, I, J, C, B.) Much less common than *M. dolomieu.*
31. **Etheostoma pellucidum** Baird. *Sand darter.* (L, B.) Common in the Big Sandy River, but very rare in Blaine Creek.
32. **Etheostoma nigrum** (Rafinesque). *Johnny darter.* (R, S.) Rare.
33. **Etheostoma blennioides** Rafinesque. *Green-sided darter.* (Bea, R, S, I, J.) Much more common than *E. nigrum.* Many of the specimens are dark green, with the markings very dark or black. Species common only in Island and John creeks. Dorsal, XIII-13, XII-13, XIII-13, XIII-13. Lateral line, 64, 69, 68, 69, 65, 64, 68, 61, 66, 64.
34. **Etheostoma macrocephalum** (Cope). (L.) Rare; only two small specimens taken.
35. **Etheostoma aspro** (Cope and Jordan). *Black-sided darter.* (L.) Not common; only four young specimens taken.
36. **Etheostoma phoxocephalum** Nelson. (L.) One small specimen taken.
37. **Etheostoma zonale** (Cope). (Bea, R, S, L, J, C.) Common, except in the Big Sandy River. Very common in John Creek. Length of five specimens: 45, 48, 47, 50, 45 millimeters. Lateral line, 43 to 50.
38. **Etheostoma cœruleum** Storer. *Rainbow darter.* (Bea, R, S, I, J, C.) Quite common at every station where found. Lateral line, 37, 38, 43, 48, 47, 40, 44, 44, 46; 26 to 28 scales, with pores.
39. **Etheostoma flabellare** (Rafinesque). (Bea, I, L, C, B.) Most common in Coon Creek, where five specimens were taken.
40. **Stizostedion vitreum** (Mitchill). *Jack salmon; Wall-eye.* (L.) Common.
41. **Stizostedion canadense** (J. B. Smith).* *Sauger.*

LICKING RIVER.

Licking River is a large southern tributary of the Ohio River. It rises in the mountains of eastern Kentucky, in Magoffin County, flows in a northwesterly direction, and joins the Ohio opposite Cincinnati. It was visited at Farmer, Rowan County, on the Newport News and Mississippi Valley Railroad. At this place the bottom is of smooth Devonian limestone, interrupted occasionally by ripples and sandbars. The surrounding country is rolling and well suited for farming, the soil producing good crops of grain, vegetables, and fruit. The river at this point is 35 or 40 yards wide, and varies in depth from 3 to 5 feet. The examination was made at a deep ripple 2 miles east of the railroad station. Very few species were obtained.

Triplet Creek, Farmer, September 9; water temperature, 71° F. Triplet Creek is a tributary of the Licking, and is about 20 miles long, and 20 yards wide near its mouth. The bed is of stone, sand, and gravel. The ripples are shallow, smooth, and swift. Collections were made one-half mile west of the railroad station and about the same distance from the mouth of the creek. The locality was a good one, twenty-seven species being taken. There is a small collection in the museum of the University of Indiana, made at Cynthiana, Harrison County, Kentucky, by Dr. James A. Henshall. These species are marked by an asterisk (*). In the following list "L" denotes the Licking River and "T" Triplet Creek:

FISHES OF THE LICKING RIVER.

1. **Ictalurus punctatus** (Rafinesque). *Fork-tailed cat.* Common in Triplet Creek; two specimens taken from the Licking River.
2. **Noturus flavus** Rafinesque. *Stone cat.* (T.) Rare.
3. **Catostomus nigricans** Le Sueur. *Stone-roller.* (T.) Quite common.
4. **Moxostoma duquesnei** (Le Sueur). *White sucker.* Not common.
5. **Campostoma anomalum** (Rafinesque). *Dough-belly.* (T.) Rare.
6. **Pimephales notatus** (Rafinesque). *Blunt-nosed minnow.* Common in Triplet Creek, but rare in Licking River.
7. **Notropis whipplei** (Girard). *Blue minnow.* (L, T.) Abundant only in Triplet Creek.
8. **Notropis megalops** (Rafinesque). *Common shiner.* (L, T.) Not common.
9. **Notropis atherinoides** Rafinesque. *Rosy minnow.* (L, T.) Not very common.
10. **Notropis dilectus** (Girard). (T.) Very rare.
11. **Notropis deliciosus** (Girard). (T.)
12. **Ericymba buccata** Cope. The most common species observed in Licking River; common in Triplet Creek.
13. **Hybopsis hyostomus** Gilbert. (L, T.) Very rare; specimens young.
14. **Hybopsis amblops** (Rafinesque). *Silver chub.* (T.) Not common.
15. **Hybopsis kentuckiensis** (Rafinesque). *Hornyhead.* (T, L.) Common.
16. **Lucius vermiculatus** (Le Sueur). *Pike; Pickerel.* (T.) One specimen taken.
17. **Labidesthes sicculus** Cope. *Brook silverside.* (T.) Not common.
18. **Lepomis megalotis** (Rafinesque). *Common sunfish.* (T.) Several large specimens taken.
19. **Lepomis pallidus** (Mitchill). *Blue sunfish.* (T.) Rare.
20. **Lepomis cyanellus** Rafinesque. *Green sunfish.* (T.) Not common. Lateral line, 48.
21. **Micropterus dolomieu** Lacépède. *Small-mouthed black bass.* (T.) Young specimens common.
22. **Micropterus salmoides** (Lacépède). *Big-mouthed black bass.* (T.) Not so common as *M. dolomieu.*

23. **Etheostoma nigrum** (Rafinesque). *Johnny darter.* (T, L.) Quite plentiful in Triplet Creek.
24. **Etheostoma zonale** (Cope). (L, T.) The most common darter at these stations.
25. **Etheostoma variatum** (Kirtland). (T.) Common.
26. **Etheostoma cœruleum** Storer. *Rainbow darter.* (T*.) Quite plentiful. Lateral line from 44 to 47; from 20 to 24 scales, with pores.
27. **Etheostoma flabellare** (Rafinesque). (L, T*.) Common. Scales, 51, 53, 48; pores, 26, 21, 20.
28. **Etheostoma blennioides.*** *Green-sided darter.*
29. **Etheostoma maculatum.***

LITTLE SANDY RIVER.

The following is a list of the species collected in the Little Sandy River by Dr. Charles H. Gilbert and Dr. James A. Henshall, in 1888:

1. *Lepisosteus osseus* Linnæus.
2. *Ictalurus punctatus* (Rafinesque).
3. *Noturus miurus* Jordan.
4. *Carpiodes difformis* Cope.
5. *Moxostoma duquesnei* (Le Sueur).
6. *Moxostoma anisurum* (Rafinesque).
7. *Moxostoma breviceps* (Cope).
8. *Cliola vigilax* (Baird and Girard).
9. *Hybognathus nuchalis* (Agassiz).
10. *Ericymba buccata* Cope.
11. *Clupea chrysochloris* Rafinesque.
12. *Campostoma anomalum* (Rafinesque).
13. *Pimephales notatus* (Rafinesque).
14. *Notropis whipplei* (Girard).
15. *Notropis deliciosus* (Girard).
16. *Notropis jejunus* (Forbes).
17. *Notropis atherinoides* Rafinesque.
18. *Hybopsis storerianus* (Kirtland).
19. *Labidesthes sicculus* Cope.
20. *Dorosoma cepedianum* (Le Sueur).
21. *Ambloplites rupestris* (Rafinesque).
22. *Lepomis megalotis* (Rafinesque).
23. *Lepomis pallidus* (Mitchill).
24. *Pomoxis annularis* Rafinesque.
25. *Micropterus dolomieu* Lacépède.
26. *Micropterus salmoides* (Lacépède).
27. *Etheostoma zonale* (Cope).
28. *Etheostoma nigrum* (Rafinesque).
29. *Etheostoma scierum* (Swain).
30. *Etheostoma pellucidum* Baird.
31. *Stizostedion vitreum* (Mitchill).
32. *Stizostedion canadense* (C. H. Smith).

Table of distribution of fishes of Kentucky recorded in this report.

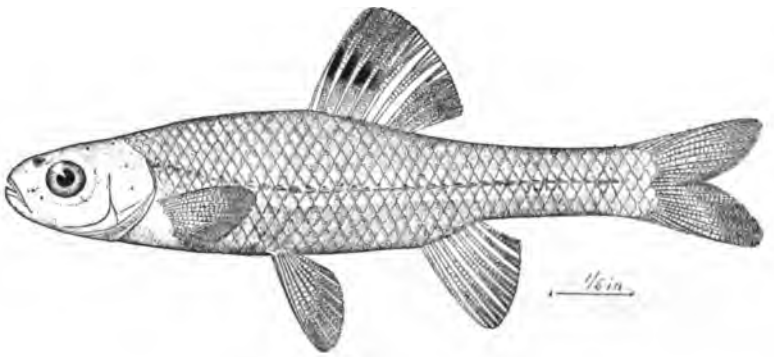
[The numbers refer to the pages where the species are recorded.]

Species.	Rolling Fork.	Lower Green River.	Upper Green River.	Tradewater River.	Lower Cumberland River.	Upper Cumberland River.	Lower Tennessee River.	Upper Tennessee River.	Mayfield Creek.	Obion River.	Bayou de Chien.	Upper Kentucky River.	Big Sandy River.	Little Sandy River.	Licking River.
Acipenser rubicundus					262		268								
Lepisosteus osseus			256	261	262		268	269		272		278		286	
platystomus				261			268				274				
Amia calva											274				
Noturus gyrinus		253							270		274				
miurus	251	253	256						270			278	283	286	
eleutherus			256												
flavus															285
Leptops olivaris	251		256			266									
Ameiurus nebulosus			256			266			270		274				
natalis			256						270						
Ictalurus punctatus	251	253	256		262		268		270	272	274	278		286	285
Ictiobus bubalus			256		262			269			274				
Carpiodes carpio	251			261											
velifer							268		270	272		278	283		
difformis					262					272			283	286	
Cycleptus elongatus					262										
Catostomus teres						266			270			278			
nigricans	251	253	257	261	262	266		269	270			278	283		285
Erimyzon sucetta oblongus				261		266			270						
Minytrema melanops			257												
Moxostoma duquesnei	251	253	256	261	262	266	268	269	270		274	278	283	286	285
breviceps														286	
anisurum														286	
Lagochila lacera						266									
Campostoma anomalum	251	253	257	261	262	266		269				278	283	286	285
Chrosomus erythrogaster						266									
Hybognathus nuchalis		253	257		262		268		270	272	274		283	286	
Pimephales notatus	251	253	257	261	262	266		269	270	272	274	278	283	286	285
Cliola vigilax	251				262								283	286	
Notropis spectrunculus						266						279			
deliciosus	251		257	261		266		269		272		278	283	286	285
whipplei	251	253	257		262	266	268	269			274	278	283	286	285
galacturus						266									
megalops	251	253	257	261	262	266		269		272		278	283		285
coccogenis													284		
ariommus	251		257									278	283		
jejunus					262					272			284	286	
umbratilis ardens			257												
cyanoce-phalus	251	253		261		266			270	272		279			
telescopus			258												
atherinoides	251	253	258	261	262	266	268			272	274	279	284	286	285
dilectus			257			266		269				279	283		285
arge			258									279			
Ericymba buccata	251					266						279	284	286	285
Phenacobius uranops			258			266									
Hybopsis kentuckiensis		253	258			266		269				279	284		285
storerianus	251	253			263		268				274			286	
amblops	251	253	258	261		266		269	270			279	284		285
dissimilis	251														
wataugа			258					269				279			
hyostomus			258										284		285
Semotilus atromaculatus	251		258			266			270			280	284		
Opsopoeodus emiliæ					263				271		274				
bollmani										272					
Notemigonus chrysoleucus									271		274				
Hiodon alosoides	251				263										
selenops	251		258												
Clupea chrysochloris														286	
Dorosoma cepedianum	251	253			263		268			273	274		284	286	
Fundulus catenatus			258		263	266		269							
Zygonectes notatus	251		258	261	263				271	273	274				
Gambusia patruelis					263					273					
Lucius vermiculatus									271	273	274				285
Anguilla chrysypa				261		266					274				
Labidesthes sicculus		253	258	261	263		268	269	271	273	274	280	284	286	285
Aphredoderus sayanus		253							271	273	274				
Centrarchus macropterus									271						
Pomoxis annularis			258	261					271	273	274			286	

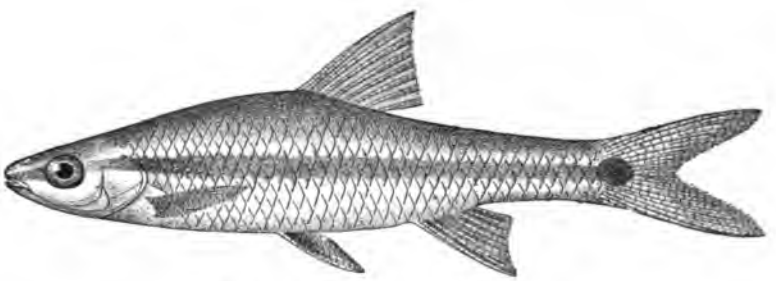
Table of distribution of fishes of Kentucky recorded in this report—Continued.

[The numbers refer to the pages where the species are recorded.]

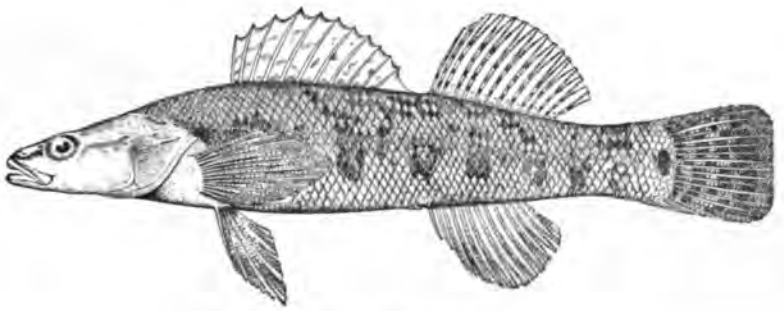
Species.	Rolling Fork.	Lower Green River.	Upper Green River.	Tradewater River.	Lower Cumberland River.	Upper Cumberland River.	Lower Tennessee River.	Upper Tennessee River.	Mayfield Creek.	Obion River.	Bayou de Chien.	Upper Kentucky River.	Big Sandy River.	Little Sandy River.	Licking River.
Pomoxis sparoides										273	274				
Ambloplites rupestris			258			266		269				280	284	286	
Chænobryttus gulosus		253							271	273	274				
Lepomis cyanellus		253			263	266			271				284		285
macrochirus				261						273					
megalotis	251	253	258	261	263	266		269	271	273	274	280	284	286	285
garmani						266					274				
pallidus		253	258	261	263	266					274		284	286	285
heros											274				
Micropterus salmoides		253	258	261	263	266				273	274	280	284	286	285
dolomieu	251	253	258	261	263	266	268	269		273	274	280	284	286	285
Etheostoma pellucidum	251	253	259		263	267		269				280	284	286	
asprellus			259												
nigrum		253	258	262			268		271		274	280	284	286	286
stigmæum			260			267									
simoterum			260			267						280			
blennioides	251		259			267						280	284		286
copelandi		253	259												
shumardi		253			263					273					
caprodes	251	253	259		263	267	268	269		273	274				
macrocephalum			259										284		
phoxocephalum	251	254	259	262	263	267			271				284		
aspro		254	259	262	263	267		269	271	273	274	281	284		
ouachitæ		254								273					
evides			260												
cymatotænia			260												
spilotum												280			
histrio		253													
variatum												280			286
scierum			260											286	
zonale	251		260			267						281	284	286	286
camurum			260			267									
maculatum						267									286
rufolineatum			260												
flabellare			260									281	284		286
cumberlandicum															
obeyense															
virgatum			260			267									
cæruleum	251	254	260			267						281	284		286
fusiforme				262					271		274				
microperca			260												
Stizostedion vitreum			260		263		268						284	286	
canadense													284	286	
Roccus chrysops					263		268								
Aplodinotus grunniens	251	254	260		263		268			273	274				
Cottus bairdi			260												



1. OPSOPŒODUS EMILIÆ Hay.



2. OPSOPŒODUS BOLLMANI Gilbert.



3. ETHEOSTOMA SPILOTUM (Gilbert).

9.—NOTES ON THE STREAMS AND FISHES OF CLINTON COUNTY, KENTUCKY, WITH A DESCRIPTION OF A NEW DARTER.

BY PHILIP H. KIRSCH.

Clinton County is one of the smallest counties in Kentucky, having an area of only about 206 square miles. It lies between the Cumberland River (to which all of its streams are tributary) and the Tennessee State line, and between the counties of Wayne on the east and Cumberland on the west. Albany is the county seat.

The surface is hilly and much broken by the deeply cut valleys of the water courses. The central Poplar Mountain range, together with a series of much lower elevations, form a watershed extending in a general northwest and southeast direction, dividing the county into two nearly equal areas. On the north of this watershed the drainage is by means of Indian and Willis creeks directly into the Cumberland River; on the south by means of Spring and Ill-will creeks into Wolf River, thence through Obeys River into the Cumberland, at Celina, Tennessee.

PRINCIPAL STREAMS OF THE NORTHERN WATER SYSTEM.

Indian Creek rises at the foot of Poplar Mountain, 4 miles northeast of Albany, flows 9 miles in a northerly direction, and empties into the Cumberland River in Russell County. It receives numerous tributaries and, in connection with Willis Creek, drains nearly the whole of the northern half of the county. The bottom lands in the upper courses are narrow and densely wooded, while in the middle and lower courses they are wider and under cultivation, and are bordered by high sloping bluffs. The channels of the tributaries are mostly through solid limestone, covered with loose, irregular rock and bowlders which have fallen from the bluffs. The channel of the main stream has a bottom of gravel, with occasional limestone shoals. Collections were made from the lower course of the main stream, and in the deep gorge below Seventy-Six Falls, in the principal western branch. At the latter point the stream has a width of 20 feet and a vertical fall of 86 feet into a deep gorge, from which the mist rises high into the air, presenting varied rainbow tints. The depth of this gorge is nearly 200 feet below the bordering hills. The bottom of the channel is composed of slate. Investigations made 2 miles above the falls resulted in the collection of only two species, *Rhinichthys atronasus* (Mitchill) and *Ameiurus nebulosus* (Le Sueur). The latter found its way into the stream from Capt. Hurt's fish pond.

F. C. B. 1890—19

Willis Creek rises 8 miles northwest of Albany, flows 7 miles in a northwest direction, and empties into the Cumberland River in Cumberland County. The bottom land is narrow and bordered by high, steep bluffs. The bottom of the channel is solid limestone; the water is shallow and swift. This stream was investigated from the "three forks" to its mouth, a distance of about 5 miles.

PRINCIPAL STREAMS OF THE SOUTHERN WATER SYSTEM.

Wolf River enters the county from Tennessee and, with a general westerly course, crosses and recrosses the State line, and finally empties into Obeys River in Tennessee. Only a few specimens from this stream were observed. Its principal tributaries are Ill-will and Spring creeks.

Ill-will Creek rises 8 miles northwest of Albany, flows south 10 miles, and empties into Wolf River. The specimens from this stream were taken by local fishermen.

Spring Creek is 3½ miles south of Albany. The three creeks forming its head waters rise, respectively, in Duval, Hog Thief, and Kogar valleys, in the southeastern part of the county. It flows in a southwest direction 10½ miles, and empties into Wolf River. The bottom lands along its course are narrow and mostly wooded. The stream runs for the most part over rough limestone, everywhere covered with loose, irregular rocks of all shapes and sizes. It is exceedingly hard to work. Collections were made from the middle course, from the mouth of Albany Branch to that of Smith Creek, a distance of 2 miles. Its principal tributaries are Smith Creek and Albany Branch.

Smith Creek rises at the foot of Poplar Mountain, 3½ miles northeast of Albany, flows south about 5 miles, and empties into Spring Creek. Its banks are mostly wooded, and the bottom of the channel is of rather smooth limestone. Like most of the streams in this region, it is fed by many springs along its course. This stream was investigated throughout its entire length.

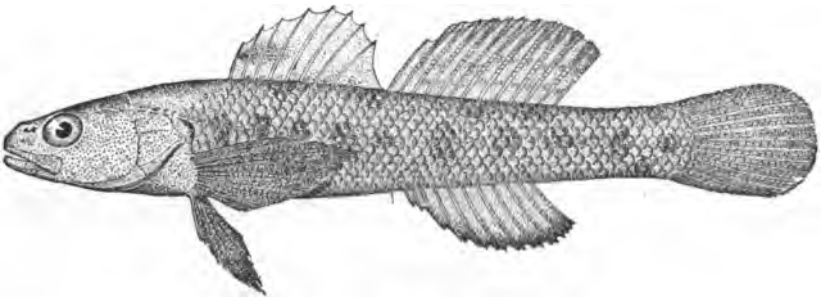
Albany Branch issues from the ground at Albany in a clear, sparkling stream 15 feet wide, flows south 3½ miles, and empties into Spring Creek. Much of the upper course is through cleared land; the bottom of the channel is limestone, mostly covered with loose rocks and gravel. It contains an abundance of fish and is easily worked. The specimens noted were from the upper and middle courses.

Nearly all the specimens on which the following list of fishes has been based were collected by the writer during the autumn of 1889 and the spring of 1890. In the notes and descriptions the following abbreviations have been employed: In denotes Indian Creek; Wl, Willis Creek; Wf, Wolf River; Il, Ill-will Creek; Sp, Spring Creek; S, Smith's Creek; and A, Albany Branch.

THE FISHES OF CLINTON COUNTY, KENTUCKY.

1. **Polyodon spathula** (Walbaum). *Spoonbill cat.* (In, Wf.)
2. **Lepisosteus osseus** (L.). *Gar-pike.* (In, Wl, Il.)
3. **Ictalurus punctatus** (Raf.). *Spotted cat.* (In, Wl.)
4. **Ameiurus nebulosus** (Le Sueur). *Catfish.* (In, S, A.) Very abundant on muddy bottom in Long's mill pond at Albany. Color, dark brown, not mottled; ventral portion light yellow.
5. **Ictiobus cyprinella** (Cuv. & Val.). *Buffalo fish.* (In.)
6. **Catostomus teres** (Mitchill). *White sucker.* (In, Wl, Wf.)
7. **Catostomus nigricans** (Le Sueur). *Hog sucker.* (In, Wl, Sp, A.) Abundant in swift water in all the streams. Especially numerous in the lower courses of Indian Creek.
8. **Campostoma anomalum** (Raf.). *"Little brown sucker."* (Wl, Sp, S, A.) Rather common; the largest specimen taken 4 inches in length. Fins plain, the dark vertical bar behind opercle not conspicuous.
9. **Chrosomus erythrogaster** Raf. *Red-bellied minnow.* (In, S, A.) Generally common, and very abundant in Albany Branch. In far the greater number the upper dark lateral band is broken up throughout its whole length into irregular spots. D. 7; A. 8.
10. **Pimephales notatus** (Raf.). *Blunt-nosed minnow.* (In, S, A.) Largest, 3¼ inches. The smaller specimens have no black spot on front of dorsal. D. 8; A. 8.
11. **Notropis whipplei** (Girard). (In.) Rare. Largest specimen taken, 3 inches long.
12. **Notropis galacturus** (Cope). (In, Wl, Sp, S.) Very common in Spring and Smith creeks. D. 8; A. 8 to 9.
13. **Notropis megalops** (Raf.). *Common shiner.* (In, Wl, Sp, S, A.) Equally common. Eighteen scales before the dorsal.
14. **Notropis leuciodus** (Cope). (S.) Five specimens taken, 2 to 2¼ inches in length.
15. **Notropis umbratilis cyanocephalus** (Copeland). (In, Wl, Sp, S, A.) Abundant in all the streams. Specimens variable in color, from almost white to a deep metallic luster. Others with dark crossbars on the sides.
16. **Notropis telescopus** (Cope). (In.) The single specimen taken is 2¼ inches long.
17. **Rhinichthys atronasus** (Mitchill). *Black-nosed dace.* (In, Wl, S, A.) Common in the upper courses of all the streams. Specimens 2 to 3¼ inches long. D. 7 to 8; A. 7 to 8.
18. **Hybopsis amblops** (Raf.). (In.) Very rare. Only one specimen taken, 2¼ inches long. Fourteen scales before dorsal.
19. **Hybopsis kentuckiensis** (Raf.). *Chub.* (Sp, S, A.) Not abundant. Dark bar behind opercle indistinct.
20. **Semotilus atromaculatus** (Mitchill). *Chub.* (In, Sp, S, A.) Especially abundant in Albany Branch. Largest taken, 11 inches long. D. 8.
21. **Clupea chrysochloris** (Raf.). (Wl.) Six small specimens were taken near the mouth of Willis Creek.
22. **Fundulus catenatus** (Storer). (In, Wl.) Abundant in Willis Creek. Those from Indian Creek highly colored. D. 13; A. 15.
23. **Anguilla chrysypa** (Raf.). *Eel.* (Il, Wf.)
24. **Ambloplites rupestris** (Raf.). *Goggle-eye.* (In, Sp, S, A.) Common.
25. **Lepomis cyanellus** (Raf.). *Green sunfish.* (In, Wl, Sp, S.)
26. **Lepomis megalotis** (Raf.). *Long-eared sunfish.* (In.) Common in the lower course of Indian Creek. D. 10–13; A. 10.
27. **Etheostoma blennioides** Raf. *Hogfish.* (In, Sp, S.) Very abundant in swift currents in Spring Creek. Specimens 3 to 6 inches long. D. XIII–12.
28. **Etheostoma caprodes** (Raf.). (Wl.) One specimen taken.
29. **Etheostoma rufolineatum** (Cope). (In.) A single specimen, 1¼ inches long; highly colored.
30. **Etheostoma flabellare** Raf. (In, S, A.) Rather common in clear, shallow water.
31. **Etheostoma cœruleum** Storer. (In, Wl, Sp, S, A.) Equally common in all the streams. Second dorsal, 12 to 13.

32. Etheostoma obeyense sp. nov. Related to *Ethcostoma flabellare* Raf., but with thicker and blunter head and different coloration. Head, 3¾; depth, 5¼ (4⅓ to 6). D. VIII-X, 12-13. A. II, 8 (7-9). Lateral line, 44 (42-45). Length, 2⅝ inches.



ETHEOSTOMA OBEYENSE.

Body rather slender, somewhat compressed, the back not elevated in adults, more so in the young. Head moderate, heavier, and less pointed than in *E. flabellare*. Interorbital space narrow; eye about as long as snout, 4 in head, the maxillary extending nearly to below its middle. Mouth rather small, little oblique. Jaws subequal, premaxillaries not protractile, the skin on middle of forehead continuous with that on tip of snout; teeth rather strong. Head, nape, and breast naked. Margin of first dorsal rounded, its longest spine 2 in base; second dorsal larger than first, its margin nearly straight, the anterior ray about 1½ in base; caudal moderate, equal in length to caudal peduncle, also to base of first dorsal, its margin subtruncate; anal smaller than second dorsal and placed opposite or slightly behind that fin; pectorals equal in length to base of second dorsal; ventrals equal in length to base of anal. Lateral line almost straight, beginning at upper edge of preopercle and extending backward, slightly descending, to past middle of first dorsal, developed on about 12 scales.

Color of adult male light-olive; dorsal region marked with seven dark crossbars, the first being on the nape and the last on the end of the caudal peduncle; on the sides are 10 or 11 irregularly shaped dark spots. Top of head dusky or black. Fins of adult males a dusky white. Black spot on membrane of first 3 or 4 dorsal spines, vanishing posteriorly; second dorsal with faint traces of bars; caudal plain; margin of anal jet black; pectorals faintly barred; ventrals dusky or black. The female and younger specimens are similarly, but more deeply, colored. Black humeral scale very large and distinct, as in *E. flabellare*. The anal, pectorals, and ventrals of the female and younger specimens are plain white, while the dorsals and caudal are distinctly barred. On the cheek is a smooth, light-colored area, extending from below the eye obliquely upward and backward to a distance twice the length of eye, and terminating at upper edge of preopercle. [This characteristic was by mistake not shown in the above cut.] This area is constricted into two parts, the anterior somewhat the larger, and everywhere bounded by a silvery band.

Very abundant in all the streams. In Indian Creek 21 specimens were taken; Spring Creek, 36; Smith Creek, 23; Albany Branch, 130. In all, 210 specimens were secured.

33. Stizostedion canadense (C. H. Smith). *"Spotted trout."* (In.) Common in the lower course of this stream.

COLUMBIA CITY, INDIANA, *November 4, 1891.*

10.—A REPORT UPON THE RIVERS OF CENTRAL FLORIDA TRIBUTARY TO THE GULF OF MEXICO, WITH LISTS OF FISHES INHABITING THEM.

BY ALBERT J. WOOLMAN.

INTRODUCTION.

During December, 1890, and January, 1891, the writer, accompanied by Prof. Louis J. Rettger, of Huntingburg, Indiana, made an examination of several of the larger rivers which empty into the Gulf of Mexico on the west side of Florida. The work was conducted under the direction of the U. S. Commissioner of Fish and Fisheries. It began in the vicinity of Punta Gorda, on Charlotte Harbor (the most southern point that could conveniently be reached), and was carried northward through the central part of the State to the tributaries of the Suwanee, in Bradford County. The fishes collected were subsequently studied at the University of Indiana, Bloomington, Indiana; annotated lists of them follow the description of each stream or river basin.

The streams examined were as follows:

1. Alligator River: The main river and the ponds and ditches near Punta Gorda.
2. Peace River: Joshua Creek, Charlie Apopka, Oak Creek, and Alligator Creek.
3. Hillsboro River: Pemberton Creek, Galliger Drain, and Mill Creek.
4. Withlacooche River: Little Withlacooche River and Pond Creek.
5. Sante Fe River: The main river, Sampson Creek, and New River.

ALLIGATOR RIVER.

Emptying into Charlotte Harbor, about 5 miles below Punta Gorda, is a small stream called Alligator River. Its proportions, however, would not entitle it to be regarded as more than a creek, except, perhaps, near its mouth, where for a mile or more small boats may ascend it without being impeded by sandbars or overhanging vegetation. The stream was visited about 5 miles from its mouth, where it was shallow enough to permit seining. Here it has cut a narrow, deep channel with very steep banks, mostly through the sand, but in places through a loose limestone. The banks are composed of fine white sand, mixed to a greater or less extent with the débris of mollusk shells. The bottom of the stream, in most places, is smooth and sandy, and quite suitable for seining. At intervals, however, there are deep basins in which the accumulated deposits of organic matter, together with a few inches of a fine black mud, combine to form a treacherous bottom for the collector. The steep banks are lined with a subtropical vegetation which overhangs the stream and makes access to it almost impossible. The average width of the stream where visited was about 15 feet,

and the average depth 4 or 5 feet. Its proximity to the harbor makes it subject to the rise and fall of the tide, which daily changes the depth of water by about 2 feet. Several species of algæ were found growing in great abundance. The predominating trees on the banks are palmettos, small live oaks, and small yellow pines. The surface of the surrounding country is level, and is dotted with small lakes and ponds. The stream flows mostly through a light woodland of yellow pines. Few species of fish were taken, the predominant forms belonging to the *Cyprinodontidæ* and the *Centrarchidæ*.

A number of ponds and large ditches in the neighborhood of Punta Gorda were also visited. They generally swarm with cyprinodonts.

In the following list the Alligator River is designated by the letter R, while the ponds and ditches near Punta Gorda are denoted by the letter P. All measurements are in millimeters unless otherwise stated.

FISHES OF THE ALLIGATOR RIVER.

1. **Notropis roseus** Jordan. (R, P.) Common. The specimens taken are smaller than the original types, and smaller than specimens obtained by Mr. Bollman at Way Cross, Georgia, in 1889; pharyngeal bones very heavy; teeth, 2, 4–4, 2; scales in lateral line, 38.
2. **Notemigonus chrysoleucus bosci** (Cuv. & Val.). (R, P.) Common. Only young specimens were secured; dark above; fins tinged with red; silver scales on sides extending to within two rows of scales of the dorsal.
3. **Opsopœodus bollmani** Gilbert. (R.) Very common. Agreeing with the original description,* except in the general color, which is somewhat darker. There is a bright, carmine-red, U-shaped mark on the snout, the arms of which reach just beyond the nostrils, the curved part just touching the premaxillary; a short line of the same color on either side of the black caudal spot; fins and sides of many of the specimens washed with red; without black edging on dorsal and anal, and without black spot on the first rays of the dorsal. The lengths of six specimens ranged from 35 to 41; scales in the lateral line, 36, 34, 35, 38, 36, 34.
4. **Lucania goodei** Jordan. (R.) Common. This is a very handsome little fish, about an inch long. The species was described by Dr. David S. Jordan in 1879, and has not since been taken until the present research. The specimens obtained at this time agree with the original description.† (See Plate LIII, Fig. 2.)
5. **Gambusia patruelis** (Baird and Girard). (R, P.) Very abundant. Found in the small brooks, lakes, and ditches, wherever there were a few inches of water. Some specimens have a dark blotch below the eye, while others are without it.
6. **Jordanella floridæ** Goode and Bean. (R, P.) Not common; only two small specimens obtained.
7. **Achirus fasciatus** Lacépède. (R, P.) Abundant. The specimens taken do not exceed 2½ inches in length, and are exceedingly variable in color.
8. **Labidesthes sicculus** Cope. *Brook silverside.* (R, P.) Common. Color, dark green; lateral stripe bright, with upper edge very dark.
9. **Chænobryttus gulosus** (Cuv. & Val.). *War-mouth.* (R, P.) Common, especially in ponds and lakes. Specimens small and very dark.
10. **Lepomis punctatus** (Cuv. & Val.). (R, P.) Not common.
11. **Gerres gula** (Cuv. & Val.). (R.) Not common. Only young specimens taken. It probably follows the tide as it ascends the river.
12. **Etheostoma quiescens** Jordan. (R.) Common. Lateral line, 48, 53, 53 or 52; scales with pores, 22, 26, 25 or 26. (See Plate LIII, Fig. 3.)

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*Bull. U. S. Fish Comm., VIII, 1888, 226. †Proc. U. S. Nat. Mus., 1879, 240.

PEACE RIVER.

Peace River, one of the largest rivers of southern Florida, rises in Polk County, where it drains a number of lakes of considerable size; thence flowing in a southerly direction for 75 miles, it empties into Charlotte Harbor. During the rainy season the water is deep and the river navigable for its entire length, but in May and June the water becomes low, and the river is fordable at many places. In December there was too much water in the channel for successful seining, and although several localities were visited, no spot was found where the net could be hauled to good advantage. The banks are low everywhere, and there is but little vegetation in the stream, except near its mouth, where it spreads out to form a large swampy tract, filled with rushes, sedges, and wild grasses. Examinations were made at Zolfo Springs, December 25, and at Wauchula and Bartow. At the first-mentioned place the river flows through a broad, low valley; its banks are precipitous and the water deep. The temperature was 63° F. Much phosphate rock occurs in that locality.

Joshua Creek is a small eastern tributary of Peace River, 12 or 15 miles long, and with an average width of 25 feet at the crossing of the South Florida Railroad, where it was examined. As in many of the Florida streams, the water appears dark-colored, owing to the decaying vegetation in the bottom of the stream, which forms a thin layer of very black sediment over the sandy bottom. The average depth of the water is, perhaps, 4 feet, although at short intervals there are "holes" which far exceed this depth. The sandy bottom is swept clean in the swifter parts of the channel, but in the more sluggish places the vegetable débris has collected to a thickness of several feet, forming a miry bottom, remarkable for the amount of marsh gas given off whenever it is disturbed. There are few ripples, but the collections of drift make it impossible for boats to ascend the stream. The banks are lined with a subtropical vegetation, and jungles of palmettos and live oaks make access to the stream especially difficult; while, owing to the steepness of the banks and the absence of sandbars, good landing-places for the seine are not numerous. Outcrops of phosphate occur in some places in the bed of the stream. This deposit seems to underlie much of the surrounding country, and is extensively mined, and shipped away for fertilizing purposes. The material resembles somewhat small water-worn pebbles of flint, but it is readily distinguished by its softness and lightness. Shark teeth and bones of other vertebrates are abundant in the phosphate rock. *Spirogyra* and other forms of algæ are common. The creek was examined at the crossing of the South Florida Railroad, about 3 miles from its mouth and near Nocatee, December 24, 1890. Temperature of water, 60° F.

Charlie Apopka is one of the largest eastern tributaries of Peace River. It rises near the northern boundary of De Soto County, and flows southwesterly a distance of 25 miles. The stream has cut its channel through the sandy soil, which in places approaches a sandstone in consistency, to a depth of from 12 to 20 feet, piling up large banks of clean white sand at every curve in its course. The current is quite swift, and the depth of water ranges from 3 to 6 feet. The bottom of the stream is composed of sand, together with coarse gravel of very soft, dark sandstone and some phosphate. No algæ were observed. Fishes were very scarce, *Fundulus seminolis* being the only abundant species. The examinations were made at Charlie Apopka Station.

Oak Creek is a small eastern tributary of Charlie Apopka, only a few miles in length, and having about the same characteristics as the main stream. *Fundulus seminolis* and black bass were the most common fishes. The collections were made near Charlie Apopka Station, December 25, 1890.

Alligator Creek empties into Peace River, and is the outlet of a small meadow lake. It is peculiar in having, for the most part, the characteristics of a prairie stream, there being no vegetation along its banks except a coarse, wild grass. The bottom is of sand, blackened by the usual vegetable mold. Its average width is about 15 feet, and its depth from 1 to 5 feet. The stream is small, but swarms with fishes, and is a good one in which to make collections. It was examined 1 mile south of Zolfo Springs, December 26, 1890; temperature of the water, 65° F.

In the accompanying list the different places visited are designated by letters as follows: Joshua Creek, J; Charlie Apopka, C; Oak Creek, O; Peace River at Zolfo Springs, P; Alligator Branch, A; Peace River at Wauchula, W; at Bartow, B.

FISHES OF PEACE RIVER.

1. **Ameiurus nebulosus** (Le Sueur). *Bullhead.* (J, A.) Not common. Very dark; almost black above; sides marbled with white.
2. **Erimyzon sucetta** (Lacépede). (J, P.) Not common. Very dark or black above, with a dark lateral band, two scales in width; somewhat lighter below, with a rose tint on breast; head, 4⅛ in length; depth, 3½; eye small, nearly 5 in head; dorsal rays, 12, the longest nearly as long as base of fin; number of scales, 39.
3. **Notropis roseus** (Jordan). (J, C, O, P, W, B.) Specimens very dark, with a light line above the plumbeous lateral band, and a pale line below; no vertebral line; base of caudal dark. The measurements of five specimens were as follows: Length, 59, 55, 55, 54, 54 millimeters; head, 11½, 11, 11, 10½, 10½ millimeters; depth, 11, 9, 9, 8½, 8½ millimeters; lateral line, 38, 38, 38, 37, or 38.
4. **Notemigonus chrysoleucus bosci** (Cuv. & Val.). (J, C, A, W, B.) Very common in Joshua and Alligator creeks. Specimens very large and fine; fins washed with red; anal edged with black; silver band very broad; scales in lateral line, 46 to 50; scales before dorsal, 25; anal rays, 16.
5. **Opsopœodus bollmani** Gilbert. (J, P, A.) Common only in Joshua Creek. Specimens taken from this stream were all large, the largest measuring as follows: Length, 60; head, 11; depth, 10½; scales in lateral line, 36; no dark spot on dorsal; body washed with red above the plumbeous lateral band; lower lip dark, almost black.
6. **Gambusia patruelis** (Baird and Girard). (J, C, O, P, A, W, B.) Common at every station. The three largest specimens measured respectively 40, 45, and 46 millimeters in total length.
7. **Mollienesia latipinna** Le Sueur. (C, O, P, A.) Not common. Only a very few specimens were taken in this river basin.
8. **Jordanella floridæ** (Goode and Bean). (J, P, A.) Not common. Two specimens were taken in Joshua Creek and three in Peace River, at Zolfo Springs. The largest measured: Length, 33; head, 8; depth, 10½. (See Plate LII, Fig. 4.)
9. **Zygonectes chrysotus** (Günther). (J, P, A, W, B.) Quite common. Specimens with or without pearly spots; dark spots on dorsal and caudal of a few specimens; cheeks iridescent; one specimen had sides marked with small black dots; scales before dorsal, 22; measurements as follows: Length, 53, 53, 46, 37, 37, 37 millimeters; head, 12, 12+, 11, 9, 9, 9; depth, 10½, 10½, 9, 7, 7, 7; eye, 3½, 3½, 3, 2½, 2½, 2½; lateral line, 35, 35, 38, 35, 35, 35. (See Plate LIII, Fig. 1.)
10. **Lucania goodei** Jordan. (W.) Only one specimen was taken; length, 31.

11. **Fundulus seminolis** Girard. (J, C, O, A, P.) Common, especially in Charlie Apopka and Oak creeks. Somewhat variable in color, and differing otherwise from the original and other descriptions.* (See Plate LII, Fig. 3.)

Body slender, not compressed; back not elevated; caudal peduncle deep; depth the same as the height of dorsal, and also equal to the distance from the end of the snout to middle of pupil; head long and pointed, somewhat pyramidal, 4⅛ to 4¼ in total length; depth of body 5¾ to 6⅛ in length, or equal to the distance from end of snout to the hinder margin of the preopercle; eye medium size, about 4 in head or two-thirds the interorbital space; dorsal fin longer than anal, the rays growing gradually shorter from the fifth to the last, giving the top of the fin a gentle convex curve; origin of dorsal above the termination of the ventrals; anal short, length of longest rays, 1⅝ that of base of fin, the fourth ray longest, growing rapidly shorter to the last; posterior margin below posterior margin of the dorsal; ventrals small and short, not reaching vent; pectorals broad, barely reaching ventrals.

Ground color, olive green in the larger specimens, brighter in the males, or of a somewhat yellowish brown, caused by the scales having dark edges. Some specimens have several longitudinal stripes resulting from dark spots in the center of the scales, but the majority of the specimens taken have no such marking. All of the young, and the older females, are crossed by 12 or 14 faint dark bars. The fins are generally plain, but in a few specimens the dorsal and caudal have darker spots, which in some instances are arranged on bars. The teeth are arranged in two rows, those of the outer row in the lower jaw much enlarged; all are pointed, movable, and curve inward. Dorsal, 17; anal, 13.

Following are given the measurements and other details of a few specimens taken in different localities: Three specimens from Joshua Creek, Nocatee: Length, 108, 100, 94 millimeters; head, 22, 22—, 21 millimeters; depth, 16, 16, 15¼ millimeters; scales in lateral line 54, 50, 52; some specimens with faint crossbars. Charlie Apopka: Very common; color light; fins without markings; lines produced by the dots at the intersection of the scales very faint. Alligator Branch: Common; color very dark; length, 112, 104; head, 27, 25; depth, 20, 19; distance from end of snout to origin of dorsal fin, 48, from origin of dorsal to end of caudal fin, 39; three bars across the dorsal; lateral line, 54.

12. **Achirus fasciatus** (Lacépède). (J, C, O, A, W.) Common, except in Alligator Creek. Color very variable.

13. **Labidesthes sicculus** Cope. Common at every station.

14. **Chænobryttus gulosus** (Cuv. & Val.). *War-mouth.* (J, C, O, A, W, B.) Common. Very dark; many specimens with the body below the lateral line decorated with copper-colored dots.

15. **Lepomis punctatus** (Cuv. & Val.). (J, C, O.) Not common. Specimens almost black; scales in lateral line, 39 to 41.

16. **Lepomis pallidus** (Mitchill). (J, P, A, W, B.) Not common. Opercle ornamented with a red spot on the posterior margin; 13 dark crossbars across the body; lateral line, 42.

17. **Lepomis holbrooki** (Cuv. & Val.). (J, C, O, P, A.) Common. Much more abundant than *L. pallidus.*

18. **Lepomis megalotis** (Rafinesque). *Long-eared sunfish.* (C, P, W, B.) Abundant wherever found.

19. **Micropterus salmoides** (Lacépède). *Large-mouthed black bass.* Taken at every station. Common in the lakes and ponds, where it is reported to grow to a great size.

20. **Etheostoma quiescens** Jordan. (J, A.) This species is described in the Proceedings of the U. S. National Museum, 1884, 479. Color, dark brown, with very dark green between the darker spots on the body. Length, 34½, 34½, 48, 52, 46, and 47 millimeters; head, 9, 9, 10, 10½, 9½, 9½ millimeters; depth, 6½, 6½, 7, 7½, 7, 7— millimeters; lateral line, 52, 49, 49, 50, 52, 50; scales with pores, 27, 21, 24, 27, 26, 22; dorsal, IX-9, IX-11, X-12, IX-10, IX-11, IX-11; anal, II-7; the spines about equal in length. (See Plate LIII, Fig. 3.)

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* Proc. Acad. Nat. Sci. Phila. 1859, p. 59. Günther, vol. VI, p. 325. Syn. N. A. Fishes, p. 334. Proc. U. S. Nat. Mus., 1884, p. 322.

HILLSBORO RIVER.

The *Hillsboro River*, one of the larger rivers of the western slope of Florida, rises in the western part of Polk County, in a low watershed that separates the rivers flowing into Lake Okeechobee from those which empty into the Gulf. It is about 45 miles long and very sluggish, but of sufficient depth to be navigable for small boats to a distance of several miles above its mouth. The country which it drains is low except about its headwaters, where it is more or less rolling. Only three places were visited on this river and its tributaries, as follows: Pemberton Creek, Galliger Drain near Seffner, and Mill Creek at Kathleen.

Pemberton Creek is a small tributary of the Little Hillsboro River, draining several small lakes and flowing for the most part through an open country. Its banks are low, the bottom is covered with a few inches of mud, and in some places with a heavy growth of algæ. Fishes were scarce, the few taken being found among the algæ and other vegetation growing in the stream. The examination was made at Seffner, December 27, 1890; water temperature, 56° F.

Galliger Drain is a large ditch-like stream, which drains several lakes and marshy prairies, and empties into Pemberton Creek. Its banks are steep and low, and the stream is narrow and deep, looking very much like an artificial waterway. It is filled in places with algæ, grass, and other vegetation. Fishes were not abundant. The Drain was examined at Seffner, December 27, 1890; water temperature, 55° F.

Mill Creek, a tributary of Hillsboro River, is a small stream, only 12 or 15 feet wide, and 2 to 4 feet deep. It was seined one-half mile southeast of Kathleen, at the "Old Mill," December 29, 1890. The stream contained much vegetation and an abundance of fishes. The water temperature was 52° F.

In the following list P denotes Pemberton Creek; G, Galliger Drain; and M, Mill Creek:

FISHES OF HILLSBORO RIVER.

1. **Lepisosteus platystomus** Rafinesque. *Gar-pike.* (M.) One large specimen was taken. Color dark brown above, decorated with darker spots, from 4 to 10 millimeters in diameter, scattered irregularly over the body and head; lighter below, but with the same black spots; opercles with a very heavy silvery pigment showing at intervals.
2. **Erimyzon sucetta** Lacépède. (M.) Rare. Black lateral band very distinct; specimens large.
3. **Ameiurus natalis** (Le Sueur). (P.) Rare. Color very light for a specimen coming from these waters.
4. **Notropis roseus** Jordan. Not common. Specimens all young.
5. **Gambusia patruelis** (Baird and Girard). (P, G, M.) Abundant. Total length of largest specimens, 50, 49, 45, 44, 44 millimeters.
6. **Jordanella floridæ** Goode and Bean. (P.) Very rare. Length, 35; depth, 11; lateral line, 27.
7. **Labidesthes sicculus** Cope. *Brook silverside.* (P, G.) Very abundant.
8. **Chænobryttus gulosus** (Cuv. & Val.). *War-mouth.* (P, G, M.) Not common. Several small specimens were taken in Mill Creek.
9. **Lepomis pallidus** (Mitchill). *Blue sunfish.* (P, G, M.) Common. Several very large specimens were obtained; the specimens from Mill Creek show eight well-defined crossbars, four scales in width.
10. **Lepomis holbrooki** (Cuv. & Val.). (M.) Rare.
11. **Lepomis megalotis** (Rafinesque). *Long-eared sunfish.* (P, G, M.) Common.
12. **Micropterus salmoides** (Lacépède). *Large-mouthed black bass.* (P, G.) Quite common.

13. **Elassoma evergladei** Jordan. (P, M.) Two very fine specimens were taken in Pemberton Creek, which differ in several particulars from the types of this species.* Total length of specimens, 25 and 27; length to caudal fin, 22½, 23; greatest height of body, 6, 7; depth of caudal peduncle, 3—, 3; length of head 6+, 7; interorbital area, 2—, 2—; eye, 2, 2; distance from tip of snout to front of dorsal, 10—, 10; number of dorsal spines and rays, III–8, III–8; length of base of dorsal, 7—, 7; longest dorsal spine, 3—, 3; longest dorsal ray, 5—, 5; anal, IV–5, IV–5; ventrals reaching to anal; number of scales, 28, 28. Ground color, very dark brown, nearly black, with three crossbars behind dorsal, between which there is a dark metallic blue; spot on opercle of a dull carmine color; two small spots of the same color at base of caudal; spots of blue on other parts of the body, notably along the lateral line; fins dark; upper half of dorsal, black; two lighter spots on the last rays of dorsal. (See Plate LIII, Fig. 4.)

    Several specimens were obtained in Mill Creek which correspond more closely with the originals. The measurements of three of these are as follows: Length, 25, 25, 23; length to base of caudal, 21, 21, 19; greatest depth, 6, 7, 5; depth of caudal peduncle, 3, 3, 3—; length of head, 6, 6+, 6—; eye, 1½, 1½, 1½; distance from end of snout to origin of dorsal, 9, 9½, 8; dorsal rays, IV–8, IV–9, IV–9; anal rays, III–5, III–5, III–5; number of scales, 27, 28, 27. Ground color dark brown, thickly covered with darker spots having no definite arrangement; a few deep lustrous blue scales on body; dorsal dark, showing in some specimens a double row of dark-red spots, forming two stripes parallel with the edge of the fin. There seems to be some variation in the size of the eye and the width of the interorbital space.

14. **Etheostoma quiescens** Jordan. (P, M.) Common only in Mill Creek. These specimens were much lighter than specimens of the same species taken in other localities. Eight crossbars pass over the back from the lateral line on one side to that on the other; a row of irregular spots below the lateral line; light spot on cheek, with irregular black spots around it; lower lip with a narrow black line on edge. Length, 47, 47, 47, 43, 43, 42, 57 millimeters; head, 9, 9, 9, 8, 8, 8—, 11; depth, 11, 11, 11, 10—, 10—, 10, 10½; lateral line, 52, 52, 51, 52, 50, 52, 52; pores, 28, 24, 27, 25, 24, 22, 22; head full-scaled, with small rough scales. (See Plate LIII, Fig. 3.)

WITHLACOOCHEE RIVER.

The *Withlacoochee River* drains a large number of lakes and low prairies in Lake County and the eastern part of Polk County. It flows in a general northwesterly direction a distance of 75 or 80 miles, and empties into the Gulf of Mexico about 20 miles south of Cedar Keys. Its headwaters were examined in three places. Three miles east of Richland the river turns nearly at right angles, changing its course from a southwest to a northwest direction; here it is about 10 yards in width, with steep banks and a swift current. The water is clear, although appearing somewhat dark, and flows over a sandy bottom. The stream at this place is almost devoid of vegetation; no crustaceans or mollusks were taken, and but few fishes. The stream was seined December 31, 1890, the water temperature being 50° F.

The *Little Withlacoochee River* was fished January 1, 1891, about 2 miles north of the station of Withlacoochee, at the crossing of the Florida Central and Peninsula Railroad. The stream at this place flows in several channels through a dense cypress swamp. The main channel is 20 feet wide, and too deep for seining. The stream was full of cypress trees and cypress knees; several species of algæ were noticed, and clinging to the logs and roots were large, brown, gelatinous-appearing masses. The surface of the country is somewhat rolling, and large ledges of coral limestone were jutting from the surface, the remains of an old coral reef. Water temperature, 48° F.

* Proc. U. S. Nat. Mus., 1884, 323.

Pond Creek is a small prairie or meadow creek, flowing through open country. The banks are low and mossy, the water clear and shallow, and the bottom of fine mud. The stream swarms with small fishes, several species of cyprinodonts being especially abundant. The examination was made at Dragem Junction, January 2, 1891; water temperature, 52° F.

In the following list species taken in the Withlacoochee River are marked W; those from the Little Withlacoochee, L; and those from Pond Creek, P:

FISHES OF THE WITHLACOOCHEE RIVER.

1. **Ameiurus natalis** (Le Sueur). (W, L.) Not common. Several young specimens were taken in both streams.
2. **Erimyzon sucetta** Lacépède. (L.) Common. Jet black above; fins all black.
3. **Notropis roseus** Jordan. (W, L.) Not common. Six specimens were obtained.
4. **Notropis metallicus** Jordan and Meek. Four specimens were taken, two adult and two young. The adults measure as follows: Length, 39, 40; head, 10—, 10; depth, 9—, 9; anal rays, 11, 11; scales in lateral line, 35, 34. For a full description see Proc. U. S. National Museum, 1884, p. 475. These specimens differ from the description in being somewhat darker in color; in having two very small red spots at the base of the caudal fin, one on the upper and one on the lower edge of the termination of the broad lateral band; in having the pectoral and ventral fins very dark; and in the absence of a distinct black caudal spot. (See Plate LII, Fig. 1.)
5. **Opsopœodus bollmani** Gilbert. (L.) One very large specimen taken; color very light, about the same as specimens of this species obtained in Kentucky. Length, 50; head, 10½; depth, 11; eye, 3; lateral line, 34; lateral band not distinct; no markings on fins.
6. **Gambusia patruelis** (Baird and Girard). (W, L, P.) Common everywhere.
7. **Zygonectes ohrysotus** (Günther). (W, L, P.) Common. Variable in color; largest specimen from Little Withlacoochee River measured, length, 66; head, 18; depth, 15; scales in lateral line, 33, without pores. Several specimens from Withlacoochee and Pond Creek measured as follows: Length, 62, 58, 56, 54, 49; head, 16, 14, 13½, 12, 11; depth, 13, 13, 12, 11½, 9; lateral line, 33, 31, 31, 33, 32. Color plain, no bars or pearly dots except on cheeks. Pearly markings oblong; many scales in lateral line with pores; cheeks iridescent; eleven distinct crossbars on body; showing crossbars; color plain; two rows of pearly dots on sides. (See Plate LIII, Fig. 1.)
8. **Mollienesia latipinna** Le Sueur. (W, L, P.) Common. Dorsal rays as long as head.
9. **Jordanella floridæ** Goode and Bean. (W, L, P.) Common. These specimens agree with the original description,* especially in regard to the generic characters. Many specimens have more than a trace of a lateral line; in the row of scales along the axis of the body a few of the scales are provided with pores; the first and second row above have a greater number, and in some cases almost all the scales in those rows have pores. Length, 50, 49, 49, 46, 43; head, 13, 12, 12, 12—, 10; depth, 18½, 19, 19, 19, 17; dorsal, I-14, I-15, I-15, I-15, I-15; lateral line, 26, 24, 26, 26, 25. (See Plate LII, Fig. 4.)
10. **Lucania goodei** Jordan. Very abundant.
11. **Fundulus ocellaris** Jordan and Gilbert. Not common. General color dark olive; body crossed by 14 dark crossbars, not as wide as the interspaces; sides above middle line covered with small spots, below dusted with minute spots. The largest specimen measured, length, 38; head, 16; depth, 11; scales, 36, of which many from the dorsal fin to the caudal are pored.† (See Plate LII, Fig. 2.)
12. **Chænobryttus gulosus** (Cuv. & Val.). *War-mouth.* (W, L, P.) Common.
13. **Elassoma evergladei** Jordan. Several specimens taken; very variable.
14. **Lepomis pallidus** (Mitchill). *Blue sunfish.* (W.) Not common.
15. **Lepomis holbrooki** (Cuv. & Val.). (P.) Common. The specimens obtained were all young.
16. **Etheostoma quiescens** Jordan. (W, L, P.) Common in the Little Withlacoochee.

* Proc. U. S. Nat. Mus., II, 1879, p. 117.

† Proc. U. S. Nat. Mus., 1882, 254.

SANTA FÉ RIVER.

The Santa Fé River is an eastern, and one of the largest, tributaries of the Suwanee River. Collections were made at three places on this river and its tributaries, in Bradford County.

The Santa Fé River is the outlet of a lake having the same name, situated in the southeastern part of Bradford County. This lake is about 11 miles long, 5 miles wide, and very deep. Three miles southwest of Hampton, a station at the crossing of the Georgia and Southern Florida and the Florida Central and Peninsula Railroad, the river is only about 20 feet wide, with an average depth of about 4 feet. Here the river flows through woodland, and is full of cypress trees, coarse grass, and algæ. A red alga, *Batrachospermum*, was found in such abundance at this place as to hinder the use of the seine. The examination was made January 3, 1891; water temperature, 51° F.

Sampson Creek is a small northern tributary of the Santa Fé, and is very shallow. It afforded very few fishes. It was examined at Sampson, January 5, 1891; water temperature, 49° F.

New River is a large northern tributary of the Santa Fé, and at the place where it was visited, New River Station, was of about the same size and character as the Santa Fé, but the water was more shallow. The bottom is sandy and black, the banks are low, and vegetation extends down to and into the water. Fishes were not abundant. Examined January 5, 1891; water temperature, 50° F.

In the following list, the Santa Fé River is designated "SF," Sampson Creek, by the letter S, and New River by the letter N.

FISHES OF THE SANTA FÉ RIVER.

1. **Ameiurus natalis** (Le Sueur). (SF, S.) Not common. Largest specimen only 3½ inches long.
2. **Noturus gyrinus** (Mitchill). *Stone cat.* (SF, S.) Rare.
3. **Noturus leptacanthus** Jordan. (N.) Three small specimens were taken, the largest measuring length, 62; head, 13; width of head, 10; depth, 10; upper jaw, projecting; color, a uniform dark brown above, lighter on belly.
4. **Erimyzon sucetta** Lacépède. (SF, S, N.) Young specimens quite common in the Santa Fé.
5. **Notropis roseus** Jordan. (SF.) Rare, and becoming less abundant farther north.
6. **Gambusia patruelis** (Baird and Girard). (SF, S, N.) Common. Most of the specimens have a spot below the eye.
7. **Zygonectes chrysotus** (Günther). (SF, S, N.) Common. Specimens large, with body barred; young with pearly dots.
8. **Zygonectes notti** Agassiz. (SF, S, N.) Common. Not found farther south. Males with twelve, vertical bars; longitudinal rope-like stripes very bright. Length, 55; head, 12; depth, 7; scales in lateral line, 35.

3 **Heterandria** [illegible] Jordan. [illegible] Not common. The original description of this species was [illegible] Proceedings, 1884, p. 253. The females of [illegible] the anal fin in the other sex. The males being [illegible] The dorsal fin has the first ray [illegible] Five specimens, two males and three females, gave the following measurements in millimeters:

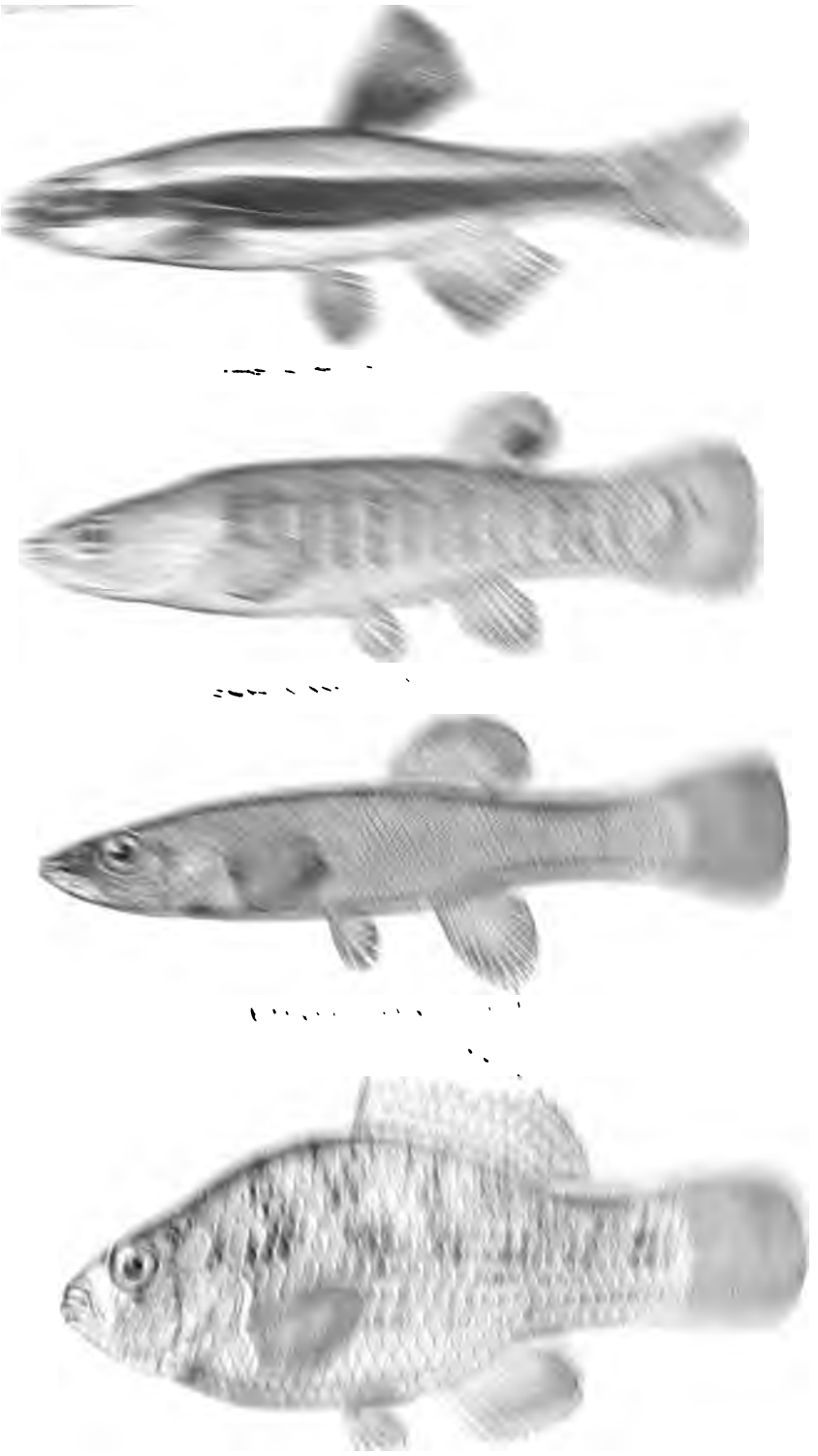
Sex	Total length.	Length to caudal fin.	Head.	Depth.	Dorsal.	Anal.	Scales.
Males	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Females	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

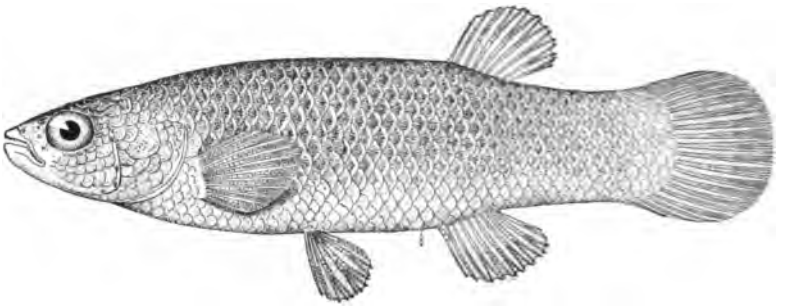
The generic characteristics of this genus are not well established, as to the affinities with both *Heterandria* (see Proc. U. S. Nat. Mus., 1884, 253; Gunther, Vol. I, 351; Proc. Acad. Nat. Sci. Phila. 1859, 62), and *Rivulus* (see Gunther, Vol. VI, 257). The specimens I have examined have more in common with *Heterandria*, but have not the anal fin modified into an intromittent organ.

10. **Aphredoderus sayanus** (Gilliams). SF. One specimen taken: length, 50; head, 18; depth, 16; number of scales, 48; dorsal, III–12; anal, II–8; vent midway between under margin of opercle.
11. **Chænobryttus gulosus** (Cuv. & Val.). SF. S. N. Common.
12. **Lepomis punctatus** (Cuv. & Val.). SF. S. N. Common. Specimens large; scales in lateral line, 43.
13. **Lepomis pallidus** (Mitchill). *Blue sunfish.* S. N. Rare. Only three specimens obtained.
14. **Lepomis megalotis** (Rafinesque). *Long-eared sunfish.* N. Not common.
16. **Etheostoma quiescens** Jordan. SF. S. N. Not abundant. Several specimens were obtained in each locality.
17. **Elassoma everglades** Jordan. SF. S. N. The color of these little fishes is exceedingly variable. The ground may vary from a light olive to a dark brown, or they may be mottled, striped, or barred with reddish brown, a dark brown, or a very dark green. Dorsal and anal fins edged with black. Several specimens had the body crossed by from 5 to 8 reddish-brown bars, which extended to the upper edge of the dorsal. See Plate LIII, Fig. 4. Six specimens from the Santa Fé measure as follows:

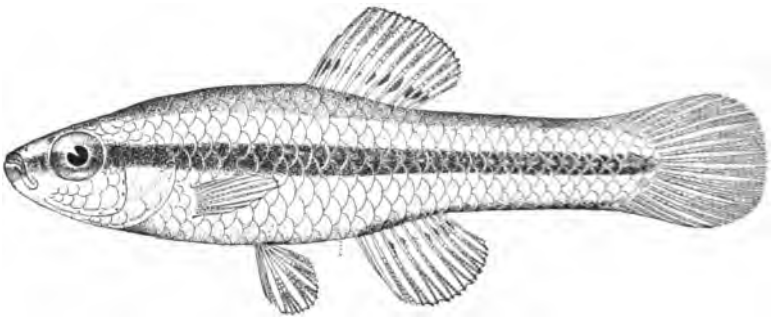
Total length.	Length to caudal fin.	Head.	Depth.	Dorsal.	Anal.	No. of scales.
25	22	6.5	6.5	IV–12	IV–7	28
26	21.5	7	6	IV–11	III–5	27
24	20.5	6	6	IV–11	III–6	29
23	20	6.5	6	IV–11	III–6	28
23.5	20.5	6	6	IV–9	III–5	28
24	21	6	6	IV–10	III–5	27

INDIANA UNIVERSITY, *Bloomington, Ind., June* 6, 1891.

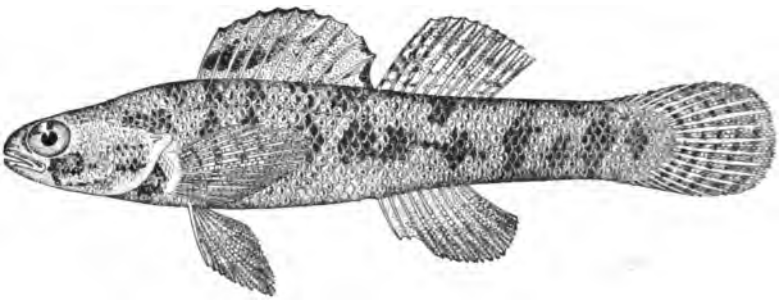




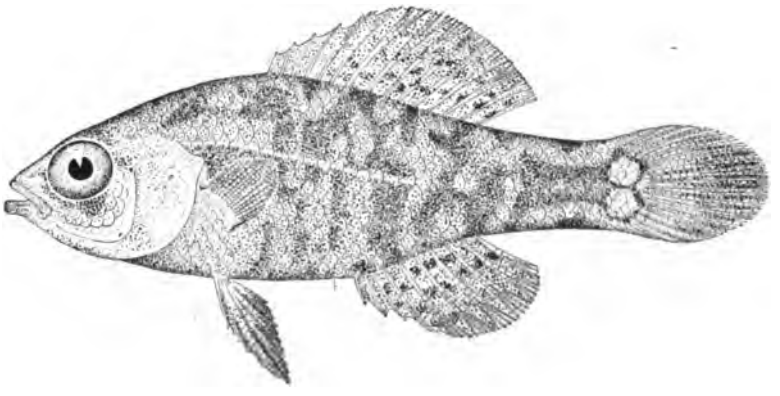
1. ZYGONECTES CHRYSOTUS (Günther).



2. LUCANIA GOODEI Jordan.



3. ETHEOSTOMA QUIESCENS Jordan.



4. ELASSOMA EVERGLADEI Jordan.

11.—AN INVESTIGATION OF THE COAST WATERS OF SOUTH CAROLINA WITH REFERENCE TO OYSTER-CULTURE.

BY JOHN D. BATTLE.

INTRODUCTORY NOTE.

[By Richard Rathbun, Assistant in charge of Scientific Inquiry.]

During the winter of 1890–91, the Fish Commission steamer *Fish Hawk*, Lieut. Robert Platt, U. S. Navy, commanding, was detailed to investigate the coast waters of South Carolina, with the object of determining the position, extent, and characteristics of the natural oyster beds, and also of the bottom areas not now producing oysters, but suitable for their cultivation. Similar surveys of the coasts of North Carolina and Georgia had previously been made by the U. S. Coast and Geodetic Survey, and the impetus thereby given to the oyster industry in those States was considered to warrant the same attention to the requirements of the intervening district. In arranging for this undertaking it was deemed advisable to add several new features to the examination, namely, a careful study of the biological characteristics of the region with special reference to the feeding of the oyster, chemical analyses of the water, and a more detailed inquiry than has been customary respecting its physical condition.

The hydrographic work, including the delineation of the natural oyster beds, the determination of suitable bottoms for oyster-planting, and the specific-gravity observations, was placed in charge of Mr. John D. Battle, formerly associated with Lieut. Francis Winslow, U. S. Navy, in the oyster survey of North Carolina, and with Ensign J. C. Drake, U. S. Navy, in that of Georgia. The services of Dr. Bashford Dean, tutor in biology in the College of the City of New York, were secured for the more special biological researches respecting the oyster and its food and the chemical and physical considerations, subjects to which he had previously given much attention in connection with the investigations of the oyster grounds of New York State. The general natural history of the waters was attended to by Mr. James E. Benedict, of the U. S. National Museum, and Mr. W. C. Kendall, the former, however, remaining with the steamer only about two months. The officers of the *Fish Hawk* participated in all the branches of the work, and their hearty coöperation, especially in regard to the hydrographic survey, was essential to its success.

Operations were begun December 23, 1890, in the neighborhood of Winyah Bay, in the northeastern part of the State. The creeks in that vicinity had already been examined by Mr. Battle in the interest of an oyster company, and the privilege of using his results being obtained, but little time was spent there. The steamer then proceeded to the Savannah River and worked thence northward to the northern part of Bull Bay, near Cape Romain, completing the survey March 30, 1891.

The coast region of South Carolina consists chiefly of very low land, marshy to a great extent, which in many places extends inland a considerable distance. It is indented or cut through by a number of sounds, bays, and river mouths, which are connected by an intricate system of winding creeks and rivers, separating the sea islands from one another and from the mainland. Oysters are found in most of the creeks and rivers which are suited to their growth, but they occur mainly as fringing ledges along the borders between the levels of high and low tide. In only a few localities do they grow naturally in the stream bed, and their cultivation or improvement by transplanting has not hitherto been attempted, except upon a very limited scale.

The water that circulates through these oyster-bearing channels is derived from several sources, the sea on the one side, the rivers from the interior, neighboring springs, and land seepage on the other. That coming from the sea has the high salinity or density of the ocean, while the rest is fresh. As is naturally to be expected from the positions and relations of these numerous bodies, their contents, resulting from the mixture of different waters, present a great diversity as regards their saltness, and the density in each is subject to great and frequent variations through the tides and seasonal changes. Moreover, the larger rivers bring down an immense quantity of sediment, which, becoming widely disseminated, fills many of the channels with highly discolored water, especially during times of freshets. From this source and probably from others also the channels have derived, over a large part of their extent, a very soft, muddy bottom, not capable of supporting heavy objects of any character.

The reason for the peculiar distribution of the oysters, above referred to, which obtains also in Georgia, in some parts of North Carolina, and on the outer coast of Virginia, has not positively been determined, but the most plausible explanation yet given to account for it would make it dependent upon the high specific gravity of the water. The heavy sediment and the soft character of the bottom may also have some influence in that respect. The solution of this question is of great practical importance, as the result will have much weight in determining the methods of oyster-culture best suited to the State, and it is proposed to give further attention to the matter at the first convenient opportunity. The problem involved is as to whether the spat derived from mature oysters planted on the bottom will attach themselves in similar situations; in fact, as to whether such beds would be self-sustaining, as they are in all the principal oyster regions farther north. The present indications are that, in the South Carolina waters whose salinity is above a certain standard, the spat or embryos, which are free-swimming during the earlier part of their existence, float only at the surface, and, therefore, have the means of attaching themselves only between the levels of high and low tide. In any case, however, a very simple and effective means of cultivation is presented in the transplanting of the raccoon oysters from the tide ledges to suitable bottoms in deeper water, where they rapidly attain a better shape and quality. The raccoon ledges are a source of seed, which, if properly protected, can be made the basis of an extensive industry, and one probably of great profit.

The total water area surveyed amounts to about 81,280 acres, or 127 square miles, of which it is estimated that about one-fourth, in its present condition, is suitable for oyster-planting. The extent of the natural oyster beds in the same area is placed at about 775 acres. Other territory, which was not examined from the lack of time, would greatly increase these figures, and much of the bottom not now regarded as favorable might be rendered so by proper treatment. Furthermore, it is believed that the marshes and flats along the coast channels are well adapted for the establishment of tidal ponds, which could readily be constructed by excavating the soft material to a slight depth, or in some places by building dikes. In this manner the oyster-producing territory could be greatly extended, and the plan suggested would give the oysterman complete control over his stock. This system of oyster-culture, however, has not yet been introduced into this country, and until experiments have been made which shall determine the best and most economical methods it is deemed inexpedient to enlarge upon the subject.

In the present report, by Mr. John D. Battle, will be found a detailed account of the hydrographic survey, including the density observations at all the localities visited. It is accompanied by seven charts showing the topography of the coast region, the location and extent of all the natural oyster beds discovered, and the specific gravity of the water in each stream. These charts are based upon the field sheets of the U. S. Coast and Geodetic Survey, the use of which for this purpose was freely granted by the Superintendent, Dr. T. C. Mendenhall. In fact, the only additions actually made to them by the Fish Commission have been the indications of the oyster beds, the specific gravities, the delineation of a few streams not previously surveyed, and some references to the depths and character of the bottom.

The report of Dr. Bashford Dean will treat especially of the character and conditions of the natural oyster beds and their environment; the food of the oyster, its character, distribution, and abundance in the region examined; and the chemical composition and physical characteristics of the water upon the oyster grounds. The account of the general natural history of the region has not yet been completed.

REPORT OF THE INVESTIGATION.

The oyster-bearing waters of South Carolina present the same characteristic features found in Georgia, consisting of small open sounds connected by a number of winding rivers and creeks which separate the sea islands from each other and from the mainland. The tides ebb and flow swiftly through these streams with a current ranging from 1 to 2 miles an hour. It was decided to conduct the hydrographic survey of this State in the same manner and by the same methods that were employed in Georgia, with the object not only of fixing the position and extent of the natural oyster beds, but also of determining the general conditions of the streams, the character of the bottom, and the specific gravity of the water.

With very few exceptions, the natural oyster beds lie along the shores in narrow strips, the greater part being left bare at low water. Care was taken that the observations, whenever practicable, should be made from half ebb to half flood, when the outer limits of the oyster beds are visible. This, coupled with the detailed topography of the Coast Survey charts, on which the work was platted in the field, enabled us to locate their positions with considerable accuracy. It would have taken several years to make a complete survey of all the streams embraced within the territory examined, but it is believed that sufficient data have been collected and are presented in this report to enable anyone who is interested in the subject to recognize without much trouble at least the majority of localities that are adapted to oyster cultivation. Pains were taken to obtain as much information as possible from the more intelligent fishermen and oystermen with whom we came in contact, especially as regards the streams not visited by the party.

The present State laws are entirely inadequate to meet the requirements of oyster-planting. A penalty is prescribed for stealing oysters from planted grounds, but there is no provision for taking and holding grounds for that purpose, and the right to such possession can only be obtained by special legislation. It is hoped that one of the results of the present survey will be to influence liberal action on the part of the State legislature to the extent of affording every legitimate means for the promotion of this important industry. Since the completion of the oyster survey of Georgia several large companies have been formed, which are now operating extensively on the coast of that State, and much ground has been leased or taken up by them. The territory which they occupy is similar in character to that occurring in South Carolina, and their experiments are being watched with much interest. None of these companies succeeded during last year in catching a set of spat on the shells or cultch thrown over in deep water, the cause of which is still subject to inquiry, but good success has been had from the use of the raccoon oyster from the ledges as a seed for planting in deep water.

The steam launches attached to the steamer *Fish Hawk* were generally employed in making the examinations, especially in the smaller streams. Soundings were made continuously during the survey, and the dredge was used occasionally along the same lines. Density observations were taken at frequent intervals both at the surface and at the bottom, the stage of the tide being carefully noted in each instance. All the data were immediately plotted on Coast Survey charts taken on the launches for that purpose, the same being subsequently transferred to clean sheets on board the *Fish*

Hawk. The presence of raccoon oyster ledges was readily detected at nearly all times of the tide, and their length and width were easily determined. The positions of submerged oyster beds were ascertained by the use of sounding or dredging apparatus or from information given by the fishermen. The territory examined extends from the Savannah River in the south to North Inlet in the north, omitting the region between Winyah and Bull bays, and a few smaller areas farther south. On the accompanying charts the natural oyster beds and the density observations are indicated in red. Four degrees centigrade has been used as the standard for the density observations, which are in all cases reduced to a temperature of 15° C. (approximately 60° F.).

DESCRIPTION OF AREAS EXAMINED.

Wright River is a narrow, tortuous stream, about 13 miles in length, with an average width of not more than 200 yards. It rises in the marshes near the Savannah River, and, flowing in a southerly direction, empties into the same river opposite Long Island. The water is thick with mud in suspension received from the Savannah River, and it becomes practically fresh 3 miles above its junction with the latter. The specific gravity of the water at the mouth, at high tide, was 1.0121 surface and 1.0133 bottom; 1 mile above the mouth at the same time of tide, 1.0104 surface and 1.0112 bottom; and at the mouth of Walls Cut, 1.0060 surface and 1.0146 bottom. Above this point the water is practically fresh, both at the surface and at the bottom. No oysters are found in this river, and the general conditions existing there preclude the possibility of successful cultivation. It deserves mention, however, by reason of its being the most southern stream within the jurisdiction of the State. The only source of salt water is the last of the flood, and even this small quantity is influenced by the freshets of the Savannah River, for in time of freshets little or no salt water could reach it.

New River is a narrow, winding stream 16 miles long, which also has a general southerly direction, and enters Tybee Roads 2½ miles north of the mouth of Wright River. It has an average width of 200 yards, and ranges in depth from 5 to 20 feet. The character of the bottom corresponds favorably with that indicated on the Coast Survey charts, being generally hard mud or sand, or sticky, with occasional soft spots. This river presents many favorable conditions for oyster-culture. The greatest drawback, perhaps, is the mud in suspension in its waters, received from the Savannah River through Walls Cut, and from its mouth on the flood tides, when the outflowing water from this river is thrust back up New River and discolors its waters to a point about 6 miles above the mouth, where it becomes clear again. This is due, no doubt, to the salt-water circulation through the Cooper River at its junction with New River, and through Rams-horn Creek, as the division of the tides occurs in New River about 1 mile below this junction.

The observations were made on the last of the flood and throughout the entire ebb tide, and it will be observed that the changes in the specific gravity of the water is marked. Commencing at its mouth with 1.0176, it declines until it reaches a minimum of 1.0107 at the surface and 1.0113 at the bottom, at a point about one-half mile above the lower mouth of Rams-horn Creek, when it begins to rise again, caused by the salt water from the Cooper River, and reaches a maximum, at the highest point examined, of 1.0157 at the bottom.

An area of scattered oysters in the bed of the river is found between the mouth of Rams-horn Creek and a point a mile below, where the river divides to make a junction again at its mouth. These oysters are large, have deep shells, and were in good condition, but they were covered with barnacles, like those found in the mouth of the Savannah River and at Winyah Bay, and, indeed, everywhere where the same conditions have been found. I have observed, too, that while these barnacles are found in large quantities on oysters taken from deep and muddy water of low density, they are not found on the raccoon oysters contiguous, which are left bare by the ebb tide for several hours. It would seem from this that, unlike the raccoon oyster, they require constant submersion to sustain life.

The only raccoon oysters observed along the shores are found between Rams-horn Creek and the mouth of the river, mainly on the western shore, in narrow patches about 10 feet wide of dead shells and living oysters, the former largely in excess, due in a measure to overfishing in this limited area. Several boats were found picking up these oysters at low water. Oyster boats were also seen tonging the single oysters in deeper water, which have also been reduced in numbers from the same cause. The greatest density observed was 1.0176 at the mouth, at half flood; the least, 1.0113 one-half mile above Rams-horn Creek, at one-third ebb. The current is very swift. The total area examined was 830 acres; area of natural oyster beds, about 21.4 acres.

Cooper River has a length of 10 miles from its lower mouth or junction with New River to its upper mouth at Calibogue Sound. It is a winding, narrow stream for the first 6 miles, of an average width of 150 yards, when it becomes a bold stream with a rapid current, and with an average width of 400 yards. Removed from the source of fresh water from the Savannah River, it receives only a limited amount from the drainage of the surrounding marshes and woods, and presents entirely different features from those of Wright and New Rivers, having, in consequence, a much greater specific gravity, which ranges from 1.0143 at its lowest mouth to 1.0247 at its upper mouth at Calibogue Sound. Little or no variation was found between the surface and bottom observations. The character of the bottom is generally favorable, being hard or sticky from its mouth to Page Island. Above this island the bottom is a very soft mud. No oysters are found in this river below low-water mark; but, along the shores on both the north and south sides, raccoon oysters occur in considerable quantities, forming a series of narrow ledges extending from high to low water mark, and not more than 10 feet wide. These ledges reach from the mouth at Calibogue Sound to a distance of 3 miles above, or to the first abrupt bend of the river. The depth of the water varies from 5 to 30 feet. The total area of the river is 960 acres; area of natural oyster beds, about 5.4 acres.

Calibogue Sound has a northward trend, and through its tributaries connects Tybee Roads with Port Royal Sound, the "divide" of the tides occurring near the mouth of Skull Creek. From its mouth at Braddock's Point to its head at the mouth of the May River, it has a length of 6 miles and an average width of 1 mile. The examination was made on the flood tide. The specific gravity near the mouth was 1.0206 at the surface and 1.0215 at the bottom; near Marsh Island, it was 1.0208 at the surface and 1.0207 at the bottom; at the head, or mouth of the May River, 1.0206 at the surface and 1.0207 at the bottom. In 9 fathoms of water at the last locality (station No. 1651) the dredge brought up a considerable quantity of small single

oysters. They were small, but of good shape, yet they had the appearance of being stunted, and were foul with sponge. The fact is a noticeable one, for it is the first and only instance on the cruise when oysters have been found in deep water of this density. The character of the bottom is favorable, and corresponds with the indications on the Coast Survey charts. Raccoon oysters extend in a narrow ledge, 10 feet wide, along the west shore from the mouth of Cooper River to the mouth of May River, but only a few are found on the east shore. The total area of the sound is about 2,944 acres; area of natural oyster beds, about 4.8 acres.

Broad Creek rises in the marshes of Hilton Head Island and, flowing westerly 7 miles, enters Calibogue Sound opposite the mouth of the Cooper River. No density observations were made in the creek, but from information received the same formation of raccoon oysters exists along the shores in ledges which were located approximately. Total area of creek, about 496 acres; approximate area of natural oyster beds, 6.5 acres.

May River, the principal tributary of Calibogue Sound, was examined from its mouth a distance of 12 miles. The topography of the Coast Survey charts had only been completed to a point 1 mile above Bluffton, and the additional part surveyed was sketched as accurately as possible. The general trend of this river is southeast, and it has an average width of three-eighths of a mile. Belonging throughout to the same system of salt-water circulation, no marked changes are noticeable at different times of the tides. The specific gravity at the mouth was 1.0206 at the surface and 1.0207 at the bottom; at the highest point reached it was 1.0205 at the surface and the same at the bottom. The character of the bottom from its mouth to Bluffton is favorable from mid channel to the south shore. On the north shore a softer bottom is found. The soundings corresponded fairly with the characteristic soundings of the Coast Survey charts. The same type of raccoon oysters are found on both shores from the mouth to, and even above, Bluffton, but 3 miles above there they disappear entirely. No oysters are found below low-water mark, except the droppings from the parent ledges, and this limited area is over-fished. I see no reason why art can not assist nature and extend this area by removing the young oysters from the ledges to deeper water and a suitable bottom. The total area of the river is about 2,000 acres; area of the natural oyster beds, about 13.1 acres.

Bull Creek is a narrow, winding stream, connecting the Cooper River with May River, and separating Bull Island from the mainland. It is about 5 miles in length, and has an average width of 150 yards. Starting with a specific gravity of 1.0210 at the surface and bottom at its lower mouth, it reaches a maximum of 1.0213 at the surface and 1.0218 at the bottom at its upper mouth. The least density observed was at a point 2 miles above the lower mouth, being 1.0206 at surface and bottom, at half flood. The bottom is favorable, being generally hard, and the soundings correspond with those given on the Coast Survey charts. The same characteristic growth of raccoon oysters occurs along the shores in narrow strips about 10 feet wide, but no oyster beds are found in deep water. Total area of creek, about 340 acres; area of natural oyster beds, about 7.6 acres.

Mackay Creek connects Port Royal with Calibogue Sound, and may be said to be a continuation of the latter. It is about 6 miles in length, and consists for the first 5 miles of a series of flats or bays of shallow water, with an average width of a quarter of a mile. Commencing with a density of 1.0214 at surface and bottom at its lower

mouth during low water, it reaches a maximum at its upper mouth, during high water, of 1.0225 at surface and bottom. No difference between surface and bottom density was observed anywhere in this creek. Raccoon oysters not only extend along the shores but are found also in patches on the mud flats. The character of the bottom for the first 3 miles above the lower mouth is favorable, being generally hard and sticky, when it becomes very soft for 2 miles, and then hard and sticky again to the upper mouth. The total area of the creek is about 904 acres; area of natural oyster beds, about 14.5 acres.

Skull Creek is a series of shallow flats, through which runs a winding channel. It separates Pinckney Island from Hilton Head Island and enters Port Royal Sound 1½ miles below the upper mouth of Mackay Creek, while the lower mouth enters this creek near its lower mouth (Mackay) and completes the circulation of the creeks between Port Royal and Calibogue Sound. The bottom is favorable and agrees closely with the Coast Survey soundings. No natural oyster beds occur in the channel, but raccoon oysters of a fine type are found not only along the shores but around the numerous islands and on the mud flats. The ledges are about 10 feet wide and are exposed at low water. At the outer edge of these ledges some fair single oysters which have fallen away from them may be taken, but local oystermen glean this narrow strip, the demand being greater than nature can supply in her slow way. The possibilities for oyster cultivation here, and in other localities of the same character and conditions, where the oysters are not subject to rapid and radical changes of density, seem good, and I know of no better plan than removing the best of these raccoon oysters, which are left bare at low tide, to deeper water and more favorable environments. The specific gravity of the water at the lower mouth at one-sixth flood was 1.0213 surface and 1.0219 bottom; 2 miles above the lower mouth it was 1.0219 at both the surface and bottom; and one-half mile below the upper mouth at the first of the flood tide, 1.0221 at both surface and bottom. The total area of the creek is about 720 acres; area of natural oyster beds, about 13.4 acres.

Port Royal Sound separates St. Helena Island on the north from Hilton Head Island on the south. It has an average width of 2½ miles, and, from its mouth to its head, at Daws Island, a length of 6 miles. It is formed by the confluence of three large tributaries, the Chechessee, Broad, and Beaufort rivers. The inlet is broad and open, and the density of the water high, being 1.0231 surface and 1.0233 bottom at the mouth of Beaufort River, two-thirds ebb; 1.0224 surface and 1.0226 bottom at the mouth of Broad River, early flood; and 1.0224 surface, 1.0227 bottom, one-half ebb, at the mouth of the Chechessee River. The bottom is generally hard and the depth ranges from 17 to 40 feet, but a strong current and exposure to the open sea, with shifting sands, render the sound unsuitable for oyster-culture. On the west shore, between the mouth of Skull and Mackay creeks, and on the east shore from Paris Island Spit to a point 2 miles above, narrow ledges of raccoon oysters are found, but no oysters are found in deep water. Area of natural oyster beds, about 3.6 acres.

Chechessee River takes its rise near the northern point of Lemon Island, and flowing in a southeasterly direction a distance of 9 miles enters Port Royal Sound at the southern end of Daws Island. For the first 4 miles it has an average width of one-fourth mile, when it becomes a broad, bold stream, seven-eighths of a mile wide. The specific gravity at the mouth during the last of the ebb tide was 1.0224 surface and 1.0227 bottom; and near the mouth of the Colleton River, early flood, 1.0221 surface

and 1.0224 bottom. The depths correspond with the Coast Survey soundings, and there is a strong tidal current. While no oysters were found in deep water the characteristic growth was found along the shores, extending in narrow ledges from near its head to the mouth. The upper part of the river was not examined, but reliable information was had from the natives of the conditions existing above the mouth of the Colleton River. The total area of the river is 2,810 acres; approximate area of natural oyster beds, 14.5 acres.

Colleton River has its rise near the west end of Callawassie Island, where it is a broad bay or flat dotted with marsh islands. Its general trend for the first 5 miles is southeast, when it makes an abrupt bend to the north, and 2 miles farther forms a junction with the Chechessee opposite the upper end of Daws Island. The specific gravity near the mouth at early flood was 1.0221 surface and 1.0224 bottom. At the head, at the same time of the tide, the specific gravity was 1.0216 surface and 1.0217 bottom. Having no large source of fresh water, the variations in density at different stages of the tide are not great. The character of the bottom is very favorable, being hard and sticky for the most part, and the depths correspond with the Coast Survey soundings. While this river was thoroughly dredged, no oysters were discovered in deep water, but it presents a good field for the transplanting of the oysters growing along the shores between high and low tide mark, to deeper water where the bottom is favorable. The total area of the river is about 1,640 acres; area of natural oyster beds, about 12.4 acres.

Okeeteet River is properly a continuation of the Colleton River and joins it at the head of the bay. The topography of the charts had not been completed beyond its mouth, but an examination was made 2 miles above and the shore line sketched in. The bottom is favorable, being hard and sticky. The specific gravity at the mouth during the early flood was 1.0212 surface and 1.0213 bottom. At the highest point reached it was 1.0215 at both surface and bottom. Total area examined, 256 acres; area of natural oyster beds, 2.2 acres.

Broad River.—This large stream, a continuation of Port Royal Sound, heads at the junction of the Coosawhatchie and Pocotaligo rivers near Hall Island, and, flowing in a southeasterly direction, enters Port Royal Sound 17 miles below this junction at the south end of Daws Island. As its name would indicate, it is a bold, broad stream, some 2 miles wide at the mouth and with an average width of 1¼ miles. The tides run very swift and strong, and a part of its bottom is covered with quick and shifting sands, which would make the cultivation of oysters in the lower part of the river unsafe. This shifting character of bottom was noted by the discrepancy between our soundings and those of the Coast Survey charts in places. The specific gravity of the water near the mouth at early flood was 1.0224 surface and 1.0226 bottom; at the mouth of Whale Branch during first of ebb it was 1.0212 at both surface and bottom; and at the head or mouth of the Pocotaligo River during half ebb, 1.0172 surface and 1.0179 bottom. It will be observed that the specific gravity of the water at the head is much less than at the mouth. This is due to the fresh water from the Coosawhatchie and Pocotaligo rivers, which drain a large area of fresh-water swamps and give the water here a dark color like that from the juniper swamps. Neither dredging nor sounding discovered oysters in deep water in the river, but the usual accompaniment of raccoon oysters is found along the shore from the mouth to the head, the ledges becoming less frequent and the oysters of poorer type as you approach the head.

The entire area of the river is about 12,274 acres: area of natural oyster beds, about 22.8 acres.

Pocotaligo River, the eastern branch of Broad River, was examined at its mouth to a point a mile above where the topography of the chart ceases, and which is a distance of 3½ miles. Its general course is south and its average width about 200 yards. The water is very darkly discolored, like swamp water, from its mouth to the highest point examined. The bottom is favorable, being hard and sticky for the greater part, and the depth ranges from 2 to 17 feet. The specific gravity at the mouth at half ebb was 1.0172 surface and 1.0179 bottom; at the mouth of Haulover Creek it was 1.0148 surface and 1.0149 bottom, and at the highest point examined 1.0145 surface and 1.0144 bottom. As one ascends the river the raccoon oyster ledges become less frequent and the type poorer until they cease altogether about 3 miles above the mouth. At two different places, namely, the mouth of Haulover Creek and a mile above it, small single oysters were taken in deep water, but they were like the raccoon oysters, poor in quality although of good shape. They have the usual attachment of barnacles, which have been found on all the oysters taken from deep water presenting the same conditions. I think it more than likely that the poor quality and condition of the oysters taken from deep water here is caused in part by the coloring matter in the water. Total area of part examined is about 300 acres; area of natural oyster beds, about 3.2 acres.

Whale Branch.—This winding stream separates Port Royal Island on the south from Barnwell and Chisholm islands on the north, and connects Broad River with the Coosaw. It has an average width of one-fourth of a mile and a distance through the Coosaw of 8 miles. For the first 5 miles it takes a northerly direction, and thence extends east to the Coosaw, of which it is a continuation. The depths range from 7 to 18 feet. The bottom from the ferry to the Coosaw River is generally hard and sticky, and therefore favorable, but the water, like that of the Pocotaligo, and coming from the same source, is darkly discolored on the ebb tide even below Port Royal Ferry. The only oysters found were along the shores and around the several islands, but these were of poor type and quality. The specific gravity of the water at the lower mouth, Broad River, during early ebb was 1.0210, surface and bottom; at the railroad bridge, 1.0193 surface and 1.0194 bottom; at its junction with the Coosaw River during early flood, 1.0198 surface and 1.0200 bottom. The total area is about 1,024 acres; area of natural oyster beds, about 11 acres.

Archer Creek is a narrow passage connecting Broad River with Battery Creek, and separating Port Royal Island from Paris Island. It is about 3 miles long and ranges in depth from 3 to 10 feet. The specific gravity at the upper mouth was 1.0228 surface and 1.0230 bottom, at half ebb. The total area of the creek is 150 acres; area of natural oyster beds, about 3.2 acres.

Beaufort River heads at the junction of Brickyard and Albergottie creeks, and, flowing in a southerly direction for 13 miles, enters Port Royal Sound at the southern point of Paris Island. For the first 8 miles, or to the mouth of Battery Creek, it has an average width of three-eighths of a mile, and from this point to the mouth a width of seven-eighths of a mile. The depths range from 3 to 30 feet, and there is a strong tidal current. The bottom agrees well in depth and character with the Coast Survey soundings, much of it being favorable for oyster cultivation, but shifting bottom may be apprehended in the broad part near its mouth. The usual growth of raccoon oys-

ters is found along the shores and around the islands in the river, but no oysters occur below low-water mark. The specific gravity at the mouth of the river at two-thirds ebb was 1.0231 surface and 1.0233 bottom; at Beaufort, 1.0226 surface and 1.0227 bottom, and at the junction of Albergottie and Brickyard creeks, one-half flood, 1.0226 surface and 1.0227 bottom. The total area of the river is about 3,840 acres; area of natural oyster beds, about 19.6 acres.

Chowan Creek is a small tributary of Beaufort River. Rising in St. Helena Island, it flows westward and empties into Beaufort River 4 miles above its mouth. It is about 5 miles long and has a depth of water ranging from 3 to 16 feet. The bottom is generally hard and sticky. Some fair oysters were taken here at the outer limit of the raccoon ledges. The specific gravity at the mouth was 1.0228 surface and 1.0230 bottom, at last of ebb, and 1.0224 both surface and bottom, near the head at early flood. The total area of the creek is 720 acres; area of natural oyster beds, 8.7 acres.

Jericho and Battery Creeks.—This tributary, called Jericho in its upper and Battery in its lower part, takes its rise in Port Royal Island near the town of Beaufort, and winding in many directions, with a general trend southward, empties into Beaufort River 5 miles above its mouth, near the terminus of the Port Royal Railroad. It is a narrow, deep stream, ranging in depth from 3 to 20 feet, and much of the bottom is well adapted to the cultivation of oysters, being hard and sticky. Very good oysters are taken here, in limited quantity, just below the outer limit of the raccoon oysters, having evidently fallen off from the latter into the deeper water.

During the examination of the coast of Georgia the previous winter, my attention was called to the fact that never in water presenting the same conditions of density as this (the general conditions are similar in the two States) were oysters found in deep water, unless they had dropped from the ledges above, and yet they grow and thrive between high and low tide mark. It is also a notable fact that there is an abundance of oyster life near the inlets in the Southern waters, as is manifested by the numerous and continuous ledges of raccoon oysters, and it may be laid down as a rule that as you approach the heads of the streams, where the specific gravity is much lower, the beds along shore become less frequent and the type of oyster becomes poorer; but when this condition is reached one may look for and expect to find deep water oyster beds. These facts were so patent that Lieut. Platt suggested a careful series of density observations at two points in this creek, to be made at different times of the tide and in different depths of water, to determine, if possible, the cause of the absence of oysters in the deeper water. These observations were conducted in cross sections of the creek opposite the railroad wharf at Port Royal and opposite the wharf of the Messrs. Brotherhood's phosphate mills in Jericho Creek, the water being also analyzed by Dr. Bashford Dean. Other experiments will be made during the spawning season to test the specific gravity of the oyster spat itself.

Other interesting experiments were undertaken in this vicinity, the outcome of which will be watched with much interest. A number of oysters were selected from the raccoon beds, which are left bare at low water, counted and carefully marked with tin tags, and transplanted to deeper water. The death rate of these will be carefully noted at a future date, and they will be examined closely to see if there has been a set of spat. Oysters from the adjacent shores were also planted in midstream on suitable bottom opposite the wharf of the Messrs. Brotherhood's phosphate works, for a similar purpose.

The specific gravity at the mouth of Battery Creek at half ebb was 1.0228 surface and 1.0230 bottom; just above the junction of Jericho and Battery creeks, early flood, 1.0223, surface and bottom; abreast the phosphate works, one-fourth flood, 1.0222, surface and bottom. The total area of the creeks is about 512 acres; area of natural oyster beds, about 9 acres.

Brickyard and Albergottie creeks.—The former of these creeks is but a continuation of Beaufort River and connects it at its northern extremity with the Coosaw River. It is about 4 miles long and has an average width of 150 yards. The bottom is generally hard and sticky, and underlaid in places by phosphate rock. The specific gravity at the upper mouth, on the early flood, was 1.0215 surface and 1.0213 bottom; and at the lower mouth or junction with Albergottie Creek, 1.0226 surface and 1.0227 bottom. No oysters were observed in the Albergottie, its bottom and sides consisting of very soft mud. The total area of creeks is 560 acres; area of natural oyster beds, 2.1 acres.

Station Creek, Story and Harbor Rivers.—The territory south of St. Helena Island, between Trenchard Inlet and St. Helena Sound, was not examined, but we know that the usual conditions of salt-water circulation exist in this system, and the natural oyster beds were not located. From the best information that could be obtained it is safe to say that ledges of raccoon oysters occur along the shores which will not average more than 10 feet in width. The characteristic soundings of the Coast Survey charts can be relied on to give an idea of the bottom.

Coosaw River.—This large tributary of St. Helena Sound is but a continuation of Whale Branch and completes the northern circulation between Port Royal and St. Helena Sound. It is about 13 miles long with an average width of 1 mile. It flows in an easterly direction and empties into St. Helena Sound at the southeast point of Morgan Island. The bottom is generally hard, consisting mainly of phosphate rock, but constant changes are being made by the phosphate dredgers. The extensive prosecution of this great industry precludes the successful cultivation of oysters within this territory, even if the conditions were very favorable. The specific gravity near the mouth during the first of the flood was 1.0206 surface and 1.0207 bottom; off the mouth of Dale Creek, 1.209 surface and 1.0211 bottom; and at the junction with Whale Branch, 1.0198 surface and 1.0202 bottom. Raccoon oysters are found along the shores but are of poor quality, there being many dead shells and a small proportion of live oysters. In the upper part, the water is tinged on the ebb tide by the swamp water coming through Whale Branch. The total area of the river is about 7,104 acres; area of natural oyster beds, about 19.6 acres.

Parrott Creek is a short arm connecting Morgan and Coosaw rivers and separating Morgan Island from Coosa Island. It is about 2 miles long and will average one-fourth mile in width. The bottom is generally hard and sticky, and the specific gravity at its mouth was 1.0209 surface and 1.0211 bottom. Phosphate rock underlies the bottom of this creek also. It is now being mined in a small way, and subject to extensive operations at any time under the phosphate laws of the State. The total area of the creek is 355 acres; area of natural oyster beds, 4.6 acres.

Dales Creek also connects Morgan River near its head with Coosaw River and separates Coosa Island from Ladies Island. It is about 4 miles long and 150 yards wide. The bottom is generally hard and sticky and the depth ranges from 11 to 15 feet. This creek is also in the phosphate region, and the Farmer's Phosphate Works are

situated on its west shore. The total area of the creek is about 290 acres; area of natural oyster beds, about 2.6 acres.

Morgan River is about 8 miles long from Dales Creek to its mouth at St. Helena Sound. Its trend is east; it has a depth of 3 to 30 feet, and will average one-half mile in width. The bottom is generally hard and corresponds with the indications on the Coast Survey charts. It is liable to be disturbed at any time by the phosphate dredgers. The specific gravity at the head of the river at dead low water was 1.0193 surface and 1.0194 bottom; at the mouth near St. Helena Sound, on the first of the flood, 1.0206 surface and 1.0207 bottom. The total area is about 2,496 acres; area of natural oyster beds, 9.1 acres.

Bull River and its tributaries.—This river is formed by the confluence of the North and South Wimbee and has a general southeast course, flowing into the Coosa River opposite Parrott Creek. The bottom is generally hard and underlaid by phosphate rock; the depth ranges from 2 to 30 feet. Several large phosphate companies are located on this river, and the bottom is extensively mined for rock. No oysters were found in deep water, but raccoon oysters of poor type extend along the shores, decreasing in quantity as one ascends both the North and South Wimbee. The water, while it is not muddy, has a dirty look with an oily scum on the surface. The specific gravity of the water at the highest point on the North Wimbee, at one-half ebb, was 1.0185 surface and 1.0183 bottom; at the highest point examined on the South Wimbee, at low water, 1.0184 surface and bottom; and at the mouth of Bull River, on the early ebb, 1.0179 surface and 1.0180 bottom. The total area is about 928 acres; area of natural oyster beds, 7.1 acres.

Combahee River also has a southeast trend and empties into the Coosa 2 miles below the mouth of Bull River. While it has all the disadvantages of Bull River, being in the phosphate region, it becomes absolutely fresh 4 miles above its mouth. The bottom is generally hard and sticky, and the raccoon oysters extend along its shores to a point 1½ miles above its mouth. One mile above the mouth of Old Cheehaw Creek the water was practically fresh both at the surface and bottom. At the mouth of Old Cheehaw Creek, at three-quarters ebb, the specific gravity was 1.0113 surface and 1.0132 bottom; and at the mouth of the river, one-half ebb, 1.0162 surface and 1.0179 bottom. Total area of oyster-producing part, 1,088 acres; area of natural oyster beds, about 5 acres.

Ashepoo River was examined only from its mouth to the mouth of Mosquito Creek, which connects this river with the South Edisto. It is about 6 miles from the mouth to this point and will average about 200 yards in width. The bottom is favorable, being hard and sticky, with a depth ranging from 2 to 30 feet. But very few oysters were observed in this river, the largest area being near the west shore about 1 mile below the mouth of Mosquito Creek. The water is slightly tinged near the mouth and grows yellowish as one ascends the stream. I was informed by native fishermen that the water is fresh about 5 miles above the mouth of Mosquito Creek. This creek itself becomes absolutely fresh 3 miles above its mouth. The specific gravity of the water at the mouth of the river at one-sixth ebb was 1.0231 surface and 1.0234 bottom; near the mouth of Mosquito Creek, one-half ebb, 1.0152 surface and 1.0154 bottom. The area of the part examined was 760 acres; area of natural oyster beds, about 12 acres.

St. Helena Sound separates Edisto Island on the north from St. Helena Island on the south and is about 8 miles wide. It is open and exposed to the northeast and southerly gales and is considered totally unfit for the cultivation of oysters, not only on account of the great density of its waters, but also of the shifting character of its bottom. Area of natural oyster beds, about 4.9 acres.

South Edisto River takes its rise in Edgefield County, drains a large extent of country, and reaches the tide-water section of the State charged with mud, entering St. Helena Sound at the southwestern point of Edisto Island. Five miles above the mouth the water is practically fresh, and no doubt during heavy freshets the fresh-water point is carried nearer to the sea. From this place to the mouth the bottom is generally hard, except in the channel, and corresponds in depth and character with the Coast Survey soundings. A bed of oysters is found just off the upper mouth of Bailey Creek, a part of which is left bare at dead low water, but the bed extends into deep water. The oysters are small and have the usual attachment of barnacles. From this point raccoon oysters extend down the east shore in patches to the mouth of St. Pierre Creek, where they cease. The specific gravity of the water 1 mile above the point of Raccoon Island is 1.0000; at the point of Raccoon Island, two-thirds flood, 1.0087; in the west mouth of Bailey Creek, two-thirds flood, 1.0120, and at the mouth of St. Pierre Creek and near the mouth of the river, at one-half ebb, it was 1.0141. The area of the river from the point of Raccoon Island to its mouth is 1,150 acres; area of natural oyster beds, about 6.3 acres.

St. Pierre Creek.—This narrow winding creek takes its rise in the central part of Edisto Island and, with a westward trend, empties into the South Edisto River 1 mile above its mouth. It is about 7 miles long, will average about 175 yards in width, and has depths ranging from 2 to 20 feet. The bottom is favorable, being hard and sticky for the greater part. The density of the water is very uniform in this creek, and much less dense than that usually found in the streams near the ocean, for the fresh water of the South Edisto is met, diffused, and rebutted by the flood tides, thus tempering the water.

The ledges of raccoon oysters are not so numerous as in water of greater density, but deep-water beds are found in several places in this creek, the largest beginning at Peters Point and extends up the creek for half a mile on the south shore, and even out to the middle of the stream. This creek has furnished more seed oysters for the different planters in the State than any other locality, according to Mr. John Griffin, who is the pioneer planter in this region and who kindly accompanied us in the examination of these creeks. I am much indebted to him for information received and shall have occasion to speak of him again in connection with his planted grounds in Bailey Creek. The specific gravity of the water at the mouth of the creek at half ebb was 1.0141; 1 mile above the mouth, 1.0138; at Peters Point, 1.0138; at the eastern mouth of Bailey Creek, 1.0130; and at the mouth of Store Creek, which is a continuation of St. Pierre Creek, 1.0120. The total area of the creek and its tributaries is about 750 acres; area of natural oyster beds, about 42 acres.

Bailey Creek is a very narrow winding stream which has one outlet at its western mouth in the South Edisto 2 miles above the mouth of St. Pierre Creek, and connecting with the latter, 3½ miles above the mouth, it separates Scanawah Island on the north from Bailey Island on the south. It is especially deserving of mention because the eastern part, for 2 miles before reaching St. Pierre Creek, contains the planted

oyster grounds of Mr. John Griffin. His operations consist in taking the seed from St. Pierre Creek and transferring it to suitable bottom in Bailey Creek. The oysters are marketed from one to two years after planting. He has about 3,000 or 4,000 bushels planted and sells about 1,000 bushels a year, which he disposes of entirely in Charleston at the rate of 75 cents per bushel. Mr. Griffin informs me that a large part of the bottom of this creek is either very soft mud or quicksand and that he can only find small areas here and there suited to his purpose. Seed oysters are so near and so conveniently obtained that he has never deposited shells to catch the young oysters, but I do not doubt that it would be feasible to do so here. The planted oysters here, as well as in St. Pierre Creek and New River, are covered with barnacles. The specific gravity of the water at the western mouth is 1.0120; 3 miles above, 1.0126; 1 mile from the eastern mouth, 1.0130; at the eastern mouth, 1.0130. The entire area of the creek is about 80 acres; area of planted grounds about 20 acres.

Dawho River connects at its western mouth with the South Edisto River, and furnishes the inland passage from the South to the North Edisto rivers. The fresh water from the South Edisto renders the upper part of this river totally unfit for oyster cultivation, and the raccoon oysters only begin to show at a point about 2 miles above the eastern mouth on the mud flats. The specific gravity of the water off the eastern mouth during the early flood was 1.0199 surface and 1.0205 bottom; 1 mile above this mouth, at the mouth of Long Creek, high water, 1.0192 surface and 1.0209 bottom. The area of the lower part of the river is about 384 acres; area of natural oyster beds, about 8.5 acres.

Steamboat Creek, called Russell in its upper part, takes its rise in the northwestern part of Edisto Island and, flowing in an easterly direction, makes a junction with the North Edisto River 5½ miles below its head. The depths correspond with the Coast Survey soundings; the bottom is hard and sticky along the sides and soft in the channel. Raccoon oysters extend along the shores in patches, and the mud flats between this creek and the Dawho River contain a labyrinth of oyster beds. The specific gravity of the water at Edisto Island post-office, at low tide, was 1.0175 surface and 1.0185 bottom; at its mouth, early flood, 1.0235 surface and 1.0212 bottom. The total area, including mudflats, amounts to about 1,360 acres; area of natural oyster beds, about 71 acres.

North Edisto River, unlike the South Edisto, is simply a short arm of the sea, and through its continuation with the Wadmelaw River, New Cut, and Church Flats, merges into the Stono River at Rantowles Creek, and furnishes an inland passage from this river to Stono Inlet. It may be said to head at Wadmelaw Point, from which place to the mouth it has a length of 7¼ miles and an average width of one-half mile. The bottom is generally hard and underlaid in places by phosphate rock. No oysters are found in deep water, but those of the raccoon type extend along the shores to the mouth of Bohicket Creek. The specific gravity of the water at the mouth of Townsend River was 1.0233 surface and 1.0234 bottom, on the last of the flood; at the mouth of Leadenwah Creek, 1.0209 surface and 1.0208 bottom, on the first of the flood; and off Wadmelaw Point, or the mouth of Dawho River, 1.0199 surface and 1.0205 bottom, during early flood. The total area from Wadmelaw Point to the mouth is about 2,112 acres; area of natural oyster beds, about 7.9 acres.

Bohicket Creek, the most southern tributary of the North Edisto on the eastern shore, was examined from its mouth to a point 6 miles above. It has a general trend

westward and will average 200 yards in width with a depth ranging from 3 to 16 feet. The bottom is generally hard and favorable for cultivation. The specific gravity is high. At the uppermost point reached it was 1.0220, surface and bottom, at half flood; at Rockville, at the same time of the tide, it was 1.0222, surface and bottom; and at its mouth, about the same time of tide, 1.0228, surface and bottom. The total area examined was about 450 acres; area of natural oyster beds, about 2.2 acres.

Leadenwah Creek heads in Wadmelaw Island and also trends westward, emptying into the North Edisto 2 miles above the mouth of Bohicket Creek. It was examined to a point 1 mile beyond the limit of the topography of the Coast Survey charts, and that part was sketched in by course and distance as accurately as possible. The bottom is generally hard while the depth ranges from 2 to 25 feet. Raccoon oysters extend along the shores for the first mile and a half, when they become less frequent and finally cease altogether. The specific gravity of the water 4 miles above the mouth was 1.0212 surface and 1.0208 bottom, on the first of the flood. The area of the part examined amounted to about 384 acres; area of natural oyster beds, about 3.2 acres.

Townsend River is the most southern tributary of the North Edisto on the west side, and is reinforced by Ocella Creek, which makes a junction with it 1 mile from its mouth. The character of the bottom is generally hard. The specific gravity of the water in this river 1 mile above the junction of Ocella Creek was 1.0230 surface and 1.0231 bottom, at high tide. At the fork or mouth of Ocella Creek, on the last of the flood, it was 1.0233 surface and 1.0234 bottom; in Ocella Creek, 1 mile above the junction with Townsend River on the last of the flood, 1.0230 surface and 1.0228 bottom; and at the mouth of the river, 1.0233 surface and 1.0234 bottom. The total area of the river and creek is about 240 acres.

McCloud Creek.—This narrow but deep creek rises to the westward of Park Island, and has a length of 6 miles and a depth of 3 to 20 feet. It empties into the North Edisto River 1 mile above the mouth of Dawho River. The specific gravity of the water 4 miles above the mouth during high tide was 1.0200 surface and 1.0194 bottom; at the mouth, on the early flood, 1.0204 surface and 1.0200 bottom. The total area of the creek is 80 acres; the area of natural oyster beds is inconsiderable.

Togodo Creek is about 200 yards wide and is formed by the junction of Little and Big Togodo creeks, 2½ miles above its mouth, or one-half mile beyond the finished topography of the Coast Survey charts. No oysters occur in deep water in the creek and very few raccoon oysters were found. These were near the mouth on the west shore. The bottom is favorable, being hard and sticky. The specific gravity, 1 mile above the fork of Little and Big Togodo creeks in Little Togodo Creek, at one-third flood, was 1.0196 surface and 1.0195 bottom; and at the mouth of Togodo Creek, one-sixth flood, 1.0196 surface and 1.0198 bottom. The total area examined was about 384 acres; the area of the natural oyster beds is inconsiderable.

Wadmelaw River is a continuation of the North Edisto River, and may be said to constitute that part included between Wadmelaw Point and the New Cut. It is about 8 miles long and consists of a series of bays or flats, dotted by numerous islands. From this point to the mouth of Rantowles Creek, or the head of Stono River, the inland passage is a narrow, winding stream, about 7 miles in length. The bottom in the Wadmelaw River is generally hard and sticky except directly in the channel. The specific gravity is uniform, being 1.0199 at the surface and 1.0205 at the bottom at the lower mouth, and 1.0197 surface at one-third flood at the upper mouth or the

mouth of Church Creek. Raccoon oysters not only occur along the shores, but the wide bays and flats are covered by a series of oyster beds which are left bare at low water and which, it is estimated, will cover one-eighth of the entire area where they are found. These oysters disappear as one approaches New Cut, and none are found from this point to the Stono River. The bottom is generally much softer in this part of the Inland Passage. The total area is about 2,450 acres; area of natural oyster beds, about 150.5 acres.

Stono River is about 16 miles long from Rantowles Creek to Stono Inlet, which is formed by the junction of this with Kiawah River. For the first 7 miles it takes an easterly direction and then a general southerly direction to the inlet, with an average width of about 400 yards. The bottom corresponds in depth and character with the Coast Survey soundings; much of it being hard enough to support the weight of the oysters, is therefore favorable for planting. This river was examined on flood tide; but few oysters were observed in the upper part, but I was informed by the pilot who conducted the *Fish Hawk* through the passage that raccoon oyster ledges occur along the shores in its more southern part. The specific gravity of the water at the head, at five-sixths flood, was 1.0179; at Buzzard Roost Point, on the first of ebb, 1.0194; at the mouth of Legare Creek, early ebb, 1.0229; and at the mouth or junction with Kiawah River, one-fourth ebb, 1.0234 surface and 1.0232 bottom. The total area of the bottom is 2,580 acres; approximate area of natural oyster beds, 14.5 acres.

Kiawah River takes its rise in the eastern part of Seabrook Island and, flowing in an easterly direction, separates Johns Island on the north from Kiawah Island on the south. It is about 7 miles long and heads in a series of mud flats. The bottom is generally hard and the depth ranges from 2 to 24 feet. The specific gravity is high. At the mouth, at one-fourth ebb, it was 1.0234 at the surface and 1.0232 at the bottom; 3 miles above the mouth, five-sixths ebb, 1.0237 surface and bottom; while at its head in the flats it reaches a maximum of 1.0242, surface and bottom, on the first of the flood. Raccoon oysters extend continuously along both shores and small beds are numerous on the flats near the head. The total area is about 900 acres; area of natural oyster beds, about 33.8 acres.

Folly River was not examined, but it presents the same features and conditions which occur in Light-house and Schooner creeks, and furnishes a circulation from Light-house Inlet through to Stono Inlet, the specific gravity being, no doubt, very similar to that found in those creeks. I am informed on good authority that the raccoon ledges are found here along the shores and on the flats also. A fair idea of the bottom can be had from the Coast Survey charts. The total area is about 700 acres.

Stono Inlet is small, and being open to the sea the specific gravity of the water is high, and a shifting bottom may be expected in times of storm. It is deemed impracticable to utilize its bottom for oyster cultivation.

Schooner and Light-house creeks head in a series of mud flats in James Island and separate this island from Morris Island. Schooner Creek flows easterly and enters Charleston Harbor on the south, while Light-house Creek takes a southeasterly course and enters the small inlet of the same name, which is only a continuation of the creek. The depth of water ranges from 2 to 30 feet, and the bottom is generally hard and sticky except in the channel near the middle, where it is softer. It will be observed that the specific gravity of the water is lower in Light-house Inlet than at any point between there and the mouth of Schooner Creek. The water there was also slightly

tinged, resulting no doubt from the waters of the Ashley and Cooper rivers being met at sea by the rising tide and forced back through this inlet. The specific gravity at the mouth of Schooner Creek was 1.0221 surface and 1.0222 bottom, on the last of the ebb; near the head of the flats, early flood, 1.0226 surface and 1.0222 bottom; and in Light-house Inlet, abreast of the light-house, one-third flood, 1.0204 surface and 1.0210 bottom. Raccoon oysters not only extend along the shores in patches, but are also found in great numbers on the mud flats. Hard-shell clams or quahogs also occur in considerable quantities in these creeks. The total area of the creeks, including the mud flats at the head, is about 820 acres The area of the natural oyster beds is about 57.5 acres, and that of the planted ground about 20 acres.

Mr. Henry Merritt is engaged in planting oysters in Light-house Creek from the beacon to a point 2 miles above. Unfortunately he was not at home when this locality was examined, and but little information could be obtained as to the extent of the planted area and the quantity of oysters marketed. But specimens of the planted oysters were taken, which showed a wonderful improvement over those occurring in the adjacent raccoon beds. The method pursued is to transplant the raccoon oysters from the borders of the creek to deeper water. The worst enemy encountered, Mrs. Merritt states, is the conch, which devastates the planted beds, sometimes destroying 50 per cent of their contents. The improvement in the quality of the planted oysters, coupled with the success of Mr. Merritt (everything about his premises indicating thrift) tends to prove that this is a good field for the transplanting of the raccoon oysters to more suitable bottoms. In fact, while his operations are restricted to a small area, he seems to be the most successful planter in the State. A scarcity of reliable labor interferes with the increase of his business, most all of the work being performed by himself.

Ashley River.—The topography of this river, as well as of the Cooper and Wando rivers, has never been completed above the city of Charleston, and the shore line had to be sketched in as accurately as possible by course and distance while the survey was being made. The Ashley River was examined to a point about 12 miles above its mouth, or 2 miles above the railroad bridge, where it becomes practically fresh. It averages three-eighths of a mile in width, and the depths range from 2 to 30 feet. The bottom is favorable, being generally hard and sticky with occasional soft places. The raccoon oyster ledges are inconsiderable along the shores of this river, and cease altogether about 2 miles above the Charleston bridge, but oysters are found in deep water near the railroad bridge, and in a cove 2 miles below it on the west shore. The specific gravity is 1.0116 at the former locality and 1.0166 at the latter. The water is yellowish, with mud in suspension, in the upper part of the river. The oysters found in deep water have the usual attachment of barnacles. There is such a wide range of specific gravity that any desired density may be obtained, but that part of the river between the railroad bridge and the Wando Phosphate Works is especially recommended as suitable ground. It is also possible that this area can be stocked by the catching of spat on bottom shells or cultch, if such is desired.

A series of density observations was made at both ends and at the middle of the Charleston bridge at different times of the tide, at the surface, mid depth, and bottom. The specific gravity of the water in the mouth off Charleston at one-half flood was 1.0217, surface and bottom; 1 mile above the Charleston bridge, one-sixth flood, 1.0198 surface and 1.0200 bottom; at the Wando Phosphate Works, one-sixth flood, 1.0188

surface and bottom; 1 mile below the railroad bridge, one-half flood, 1.0137 surface and bottom; and at the railroad bridge, 1.0089 surface and 1.0116 bottom. The total area of the part examined was about 2,600 acres; area of natural oyster beds, about 10.4 acres.

Cooper River was examined and sketched in to a point about 16 miles above its mouth at Charleston. It will average about one-half mile in width with a range of depth from 3 to 30 feet. The bottom is generally favorable in the lower part, being usually hard and sticky. But few raccoon oyster beds were found along the shores, but from local information it was learned that oysters are taken from deep water in Slack Reach and farther up the stream in Groves Creek. A series of density observations was also made across this river at the custom-house dock, buoy No. 3, mid stream, and a point on the opposite shore being in range. The specific gravity at the mouth at ebb tide was 1.0224, surface and bottom; at the mouth of the Wando River, last of the ebb, 1.0213, surface and bottom; 5 miles above the mouth, early flood, 1.0192 surface and 1.0203 bottom; 12 miles above the mouth, last of ebb, 1.0168 surface and bottom; and at the highest point reached, 2 miles above Slack Reach, 1.0156 surface and bottom, on the early flood. The area of the part examined was about 6,052 acres; area of natural oyster beds, about 10.9 acres.

Wando River, unlike the Ashley and the Cooper, does not drain an extensive territory, and hence has a much higher and more uniform density. It was examined and sketched in to a point about 16 miles above the mouth. It has a general southerly direction, and empties into the Cooper River opposite Drum Island. For the first 8 miles it has an average width of one-half mile, and then begins to narrow, contracting at the highest point reached to a width of 150 yards. Raccoon oysters were found growing continuously on both shores as far as the uppermost place examined, but no oysters were discovered in deep water except the droppings from the ledges, and among these some fine specimens were obtained. The bottom is generally hard and favorable, underlaid in places by phosphate rocks, while the depth ranges from 2 to 30 feet. The specific gravity at the mouth of the river on the last of the ebb was 1.0213, surface and bottom; 4 miles above the mouth, on the last of the ebb, 1.0208, surface and bottom; near village wharf, early flood, 1.0206, surface and bottom; and at the highest point examined, one-third flood, 1.0201, surface and bottom. Little or no variation was found in the surface and bottom densities, and I have seen no locality of the same specific gravity where the conditions seem to be more favorable. How far the mining for phosphate rock in the future would interfere, can not be predicted, but parties are now taking some rock from the bottom of this river. The approximate area of the part examined is about 4,992 acres; approximate area of natural oyster beds, 34.8 acres.

Charleston Harbor is about 1½ miles wide at its mouth, from Cummings Point to Fort Moultrie, and about 3 miles long from its mouth to the mouth of Cooper River. It is exposed to southerly and easterly gales. The specific gravity ranges high, and is tempered in its upper part on the ebb tide by the water from the Ashley and Cooper rivers. A few raccoon oyster beds are found on both the eastern and western shores, but extensive dredging with the launches and with the steamer *Fish Hawk* failed to discover any oysters in deep water, and its value as a possible oyster ground is deemed inconsiderable. The specific gravity at the mouth of Cooper River was 1.0224, surface and bottom; at the mouth of the Ashley River, on the last of the ebb, 1.0217 surface

and bottom; at the mouth of Schooner Creek, at last of the ebb, 1.0221 surface and 1.0222 bottom; and at the mouth of Sullivan Island Narrows, at one-half ebb, 1.0207. The area of the natural oyster beds is 3.8 acres.

Sullivan Island Narrows.—This name is given to the narrow inland passage connecting Charleston Harbor with Breach Inlet. It is about 3 miles long, and will barely average 100 yards in width, with a range in depth of 1 to 15 feet. The bottom varies from hard and sticky along the shores to soft mud in the channel. That part lying between the channel and the shore is suitable for cultivation. The specific gravity at the lower mouth, one-half ebb, was 1.0207; 2 miles below upper mouth, at the same time of the tide, 1.0203 surface and 1.0202 bottom; and at the upper mouth or Breach Inlet, about the same time of the tide, 1.0205 surface and 1.0209 bottom. The total area of the narrows and its tributaries is 120 acres; area of natural oyster beds, 7.2 acres.

Breach Inlet, a small and insignificant inlet, is formed by the confluence of Sullivan Island Narrows, Goat Island Creek, Little Goat Island Creek, and Meeting Reach, a ramification of creeks which intersect the marshes between Charleston Harbor and Grays Bay and connect with that bay through their various drains and tributaries.

Goat Island Creek is the largest of the tributaries of Breach Inlet, and rises about 3 miles north of it in a mud flat or bay. The water has a yellowish tinge. The specific gravity at the mouth, at one-half ebb, was 1.0205 surface and 1.0209 bottom. Raccoon oysters are found in patches along the shores and also in the mud flat at the head. The total area of the creek is 140 acres; area of natural oyster beds, about 5.8 acres.

Little Goat Island Creek heads in the vicinity of Grays Bay and, with a trend southward, enters Breach Inlet one-fourth of a mile east of the mouth of Goat Island Creek. The bottom is generally hard and sticky. The lower part, from its mouth to a point 1 mile above, contains the planted grounds of Mr. Thomas Swinton. When this locality was visited Mr. Swinton was absent, and the only information regarding his operations was obtained from a negro who is sometimes employed by him in connection with the planting. This man informed me that he had never used the raccoon oysters, but secured all his planting stock from St. Pierre Creek. I also had it from the same source that Mr. Swinton was going out of the business, and that the property was for sale. Mr. Swinton disposes of about 1,000 bushels a year, and it requires from one to two years after they are transplanted before they become marketable.

No young oysters were found on the planted oysters secured here. The water was yellowish with mud in suspension and is said to be always so. The specific gravity of the water at Swinton's oyster-house at one-half ebb was 1.0200 at the surface and 1.0202 at the bottom, and at the mouth of creek, one-half ebb, 1.0198 at the surface and 1.0201 at the bottom. The total area is about 80 acres; area of planted oyster ground, about 20 acres; area of natural oyster beds, inconsiderable.

Meeting Reach.—This creek, through the Seven Reaches at its eastern extremity, connects Breach Inlet with Dewees Creek and furnishes a part of the inland passage to Bull Bay. For the first 2 miles it is a continuation of Breach Inlet and has a width of 150 yards, when it becomes very narrow and at dead low water it is almost dry. The bottom is variable, and the range of depth from 6 inches to 15 feet. The specific gravity at the lower mouth was 1.0198 surface and 1.0201 bottom, at one-half ebb;

2 miles above, 1.0199, at surface, and 1.0200, at bottom, about the same time of the tide; at junction with Morgan Creek, one-half flood, 1.0199 surface and 1.0210 bottom; and in Dewees Creek, at the mouth of Seven Reaches, at one-half flood, 1.0201 surface and 1.0207 bottom. The total area of passage to Dewees Creek is about 184 acres; area of natural oyster beds, about 9.6 acres.

Dewees Creek.—Only a portion of this creek was examined, while Grays Bay and Hamlin and Copahee Sounds were not surveyed, but we know that they have a salt-water circulation and that the only fresh water which tempers this area must come from the drainage and seepage of the surrounding marshes and woods. Hence the specific gravity will average high and, no doubt, will vary but little from the observations taken through the inland passage south of these sounds. I am informed by the Messrs. Magwood, managers respectively of the Bull Bay and the Edisto Fish and Oyster companies, that the characteristic ledges of raccoon oysters are found not only along the shores of the creeks, but also in the shallows of the numerous sounds and bays between this creek and Bull Bay. The area can be arrived at approximately and will add largely to the acreage of the natural oyster beds in the State.

The specific gravity at the mouth of the Seven Reaches at one-half flood was 1.0201 surface and 1.0207 bottom. An idea of the bottom can be obtained by reference to the Coast Survey charts. I do not see why the deeper portions of these bays and sounds where the bottom is hard and stable could not be utilized, and in course of time they probably will be, notwithstanding they are so far distant from a market and are now surrounded by uninhabitable marshes for the most part. The total area of the creek, Grays Bay, Hamlin, and Copahee Sounds is about 2,500 acres. The area between Dewees Creek and Bull Bay consists of a series of bays, sounds, inlets, creeks, and passes, through which there is a narrow intricate inland passage. The same conditions exist here which are found in the area between Dewees and Breach Inlet. There is but little variation in the density, either at the surface or the bottom. The bottom through this passage corresponds with the soundings of the Coast Survey, both in its character and depth, and is variable, being generally hard along the shores and soft in the channel.

The specific gravity at Bullyard Sound, one-half mile from the lower entrance, at one-half flood, was 1.0200, surface and bottom; near the upper entrance, 1.0200, surface and bottom; at the junction of Whiteside and Capers creeks, 1.0214, surface and bottom; at the lower mouth of Santee Pass, two-thirds flood, 1.0200, surface and bottom; at Videls Landing, at two-thirds flood, 1.0202, surface and bottom; Santee Pass near Mark Bay, three-fourths flood, 1.0214 surface and 1.0213 bottom; Santee Pass, at the Edisto Fish and Oyster Company's planted grounds, 1.0223 surface and bottom. This company is transplanting the raccoon oyster to deeper water here with fair success. A specimen of their stock which had been planted about one year was secured. In Price Creek, at the lower mouth of Bull Narrows, the density was 1.0206 surface and 1.0209 bottom; 1 mile above Price Creek and Bull Narrows, at three-fourths flood, 1.0202 surface and 1.0211 bottom; in Bull Creek, at the mouth of Bull Narrows, 1.0194 surface and bottom; at the mouth of Bull Creek, at low water, 1.0197 surface and 1.0198 bottom; and at high water, 1.0190 surface and 1.0218 bottom. It was noteworthy that all through this inland passage the water had a yellow tinge of mud in suspension, the cause of which will be spoken of later, and I think can be traced in part to the muddy water from the Santee and Pedee rivers.

The total area of this section, including bays, creeks, and sounds, is about 2,600 acres. The approximate area of natural oyster beds through the inland passage is about 15.5 acres. The numerous bays, sounds, and flats which lie north of the inland passage, and which were not examined, would largely increase the acreage of natural oyster beds and furnish a large supply of seed oysters.

Bull Bay.—This bay is about 6 miles long from Bull Bay Light to the western point of Raccoon Key at the mouth, and will average 3½ miles in width. It is very shallow except in the numerous narrow channels. Shifting sands cover the larger portion of this area, and, being open to the sea, it is subject to constant changes. It has more than ordinary interest, because two of the largest oyster companies in the State are engaged in cultivating oysters there, namely, the Bull Bay Oyster Company, which has planted the reef on which stands the lighted beacon in the northern part of the bay, and the Edisto Fish and Oyster Company, occupying the small reef, lying about one-fourth of a mile west of that place. The former company since it began operations has planted in all about 35 acres; the latter about 10 acres, the greater part of which is left bare at low water. The shifting sand is slowly but surely encroaching on these grounds, and will eventually wipe them out. The Messrs. Magwood Brothers, the managers of these companies, are aware of the changes going on and are fearful of the final result.

Density observations were made across this bay at intervals of 1 mile from the mouth of Bull Creek to the planted grounds, and it will be observed that the least specific gravity was found on the latter. The water in this bay is also discolored with mud in suspension. About a bushel of material was obtained from the planted grounds, but the bulk consisted mainly of dead shells. Only about 30 oysters were found in the lot, and these were in a very poor condition, being thin and watery. Conchs are very destructive to the oysters and the beds require constant watching to prevent their depredations. Many living oyster drills were found in the rubbish taken, but there were little or no signs of the shells having been bored by them. Raccoon oysters and dead shells occur all around the margin of the bay. While we were in this locality Mr. Magwood, the manager, took to Charleston a load of oysters obtained not from his planted grounds, but from what is known locally as the Horn, situated to the northward of Cape Romain. These oysters were much finer than the planted oysters here, and evidently came from the brackish water of the Santee River. Except Winyah Bay and vicinity, this was the highest point to the northward that was examined.

The specific gravity of the water 1 mile from the mouth of Bull Creek, at one-third flood, was 1.0236; 2 miles from the mouth, 1.0226; 3 miles from the mouth, 1.0215; 4 miles from the mouth, 1.0216; and at the Bull Bay Oyster Company's grounds, 1.0196, surface and bottom, at one-third flood. The area of the planted grounds is about 45 acres; area of natural oyster beds around the bay, about 13.3 acres.

Referring again to the yellow tinge of mud found in all the waters between Sullivan Island and Bull Bay, including the latter, it is a noteworthy fact that as the steamer *Fish Hawk* proceeded up this coast from Bull Bay to Winyah Bay the water was thick and yellow all along the coast, close to shore, the yellowish tinge growing fainter off shore until it merged gradually and imperceptibly into the green sea water. As the steamer passed through the different gradations of color in our progress toward Winyah Bay, density observations were made, which showed a great variation in the specific gravity to a point 8 miles from Georgetown Light, where it was practically fresh. This was caused by the immense volume of fresh and muddy water discharged through the

mouth of the Santee River and through the inlet of Winyah Bay, and which is undoubtedly an important factor in the discoloration of the water for many miles south, accounting in part, perhaps, for the variation of the specific gravity observed. The extent of its distribution is, no doubt, dependent on long-continued northeast gales.

Winyah Bay and vicinity.—This territory was granted or leased to Messrs. Hazard, Alexander, and Donaldson by the State legislature of 1889, for the purposes of oyster cultivation, and was surveyed in detail by the writer before the examination by the Fish Commission. Additional observations have been made, however, and are included in the following descriptions.

Winyah Bay, formed by the junction of the Peedee, Black, and Waccamaw rivers, is totally unsuitable for oyster cultivation, on account of the quantity of fresh water flowing into it from these rivers.

Muddy Bay is a part of Winyah Bay and lies between Marsh Islands and the marshes to the northward and eastward. It is a shallow bay or cove, and receives through the Peedee River a large volume of fresh and muddy water, which is constantly making a deposit of exceedingly soft material on the bottom. The water of this bay is entirely too fresh for the cultivation of oysters, to say nothing of the unsuitable character of the bottom. This limits the ground to that portion of the various creeks which flow through the marshes between the bay and North Inlet, where favorable conditions may be found. North Inlet, on the other hand, presents a very salt condition of the water, and its bottom is covered by quick and shifting sands blown in by fresh northeast winds. This character of bottom is even more dangerous to the oyster than soft mud, which may be remedied by throwing a sufficient quantity of shells up on it to give it the proper consistency for bearing up the weight of oysters.

Within this large area two separate and distinct features present themselves: (1) Soft, muddy bottom, over which flows fresh and muddy water in the more southern and western portions of the creeks; (2) salt water flowing over quicksands in their most northern and eastern parts. In the former there is the accompanying evil of those conditions producing organisms which not only lessen the supply of food by sharing it with the oyster, but clog and foul the shells themselves, and by making them unsightly render them unfit for the raw-box trade, or to be opened on the shell. Notwithstanding the unfavorable character of the place, a small area of oysters is found in Muddy Bay off the mouth of No Man's Friend Creek. The conditions barely enable the hardiest to live, and those which survive constitute a very small proportion of the bulk of the shells whose tenants have succumbed. The conditions, already unfavorable, are rendered even more so by heavy freshets in the Peedee River, which, coupled with prolonged southwest winds, destroy large quantities of oysters in the more southern portions of the creeks by forcing the fresh and muddy water through the several outlets of Muddy Bay, toward North Inlet. Two of these outlets connect Muddy Bay with Oyster Bay. One, small and insignificant, called the Haulover Creek, has been produced artificially by cutting through the marshes between the bays. The other, No Man's Friend Creek, is a bold stream through which the tides ebb and flow swiftly. These two creeks furnish the supply of fresh water to Town Creek and its tributaries. The other two outlets into Muddy Bay are the lower mouths of Jones and Sign creeks, which enter Muddy Bay south of Oyster Bay.

Oyster Bay, lying to the northward and eastward of Muddy Bay, is a shallow mud flat of considerable area. Being nearer to the supply of salt water from North Inlet,

it presents more favorable conditions, as is shown by the large number of raccoon oysters which cover about one-fifth of the entire area, a part being left bare at low water. These oysters are small and of poor quality, and are covered by barnacles. The water of this bay is very fresh in its normal condition and subject to radical changes in density in time of freshets. The bottom is also too soft, and its general characteristics render it unsuitable for cultivation. Along the northeast shore of the bay are three outlets to Town Creek, namely, Mud Creek, the Cutoff, and Sawmill Creek. The first two are small narrow streams, the last a bold stream with a swift current. The specific gravity of the water at the upper mouth of No Man's Friend Creek was practically fresh at the surface and 1.0114 at the bottom, while one-fourth of a mile southeast of this position, in the bay, it was 1.0041 surface and 1.0138 bottom. The water is always yellow from the mud held in suspension.

Sawmill Creek heads in the northeast part of Oyster Bay and winds through the marshes to a point where the Cutoff enters it and where it makes a junction with, and is called, Town Creek. The character of the bottom is favorable, being hard and sticky generally, and the depth ranges from 3 to 16 feet. Very few raccoon oysters are found along the shores, but oysters and dead shells covered with barnacles occur at places extending from shore to shore. This area has been very much overfished, and the "nubbings" have been thrown back on the bottom, not only furnishing points of attachment for barnacles, but also rendering the bottom very foul. The specific gravity of the water is variable and subject to radical changes, caused by the freshets in the Peedee River; at the lower mouth, near Oyster Bay, it was 1.0235 in January, while at the time of our last visit, in March, during the spring freshets, the water was practically fresh. Near the mouth of Clam Bank Creek, in January, the density was 1.0235 surface and 1.0244 bottom, but in March it had become practically fresh, both at the surface and bottom.

Clam Bank Creek is a small stream which connects Sawmill Creek with Town Creek. The narrow mouth where it enters Sawmill Creek does not admit a large volume of fresh water, and a part of the bottom is very favorable for cultivation. While oysters are not found in deep water, raccoon oyster ledges extend along the shores. The specific gravity at the lower mouth was 1.0235 surface and 1.0244 bottom, and at Mr. Donaldson's oyster house, on the first of ebb, 1.0227. In this creek also a great change in density was found in March.

Town Creek is a continuation of Sawmill Creek, and, flowing through the marshes, enters North Inlet at its junction with Jones Creek. The bottom is either too quick or soft for cultivation from its junction with Sawmill Creek to a point above the mouth of Sixty Bass Creek; but below this point several areas of suitable bottom are found. No oyster beds occur in deep water, except those which have been planted, but raccoon oysters are found along the shores and are left bare at low tide. These oysters improve in quantity and quality toward the mouth of the creek. In the mouth of Old Man Creek the specific gravity of the water in March, during the period of freshets, was 1.0166 surface and 1.0194 bottom, at one-third ebb; near the mouth in January, at the last of the flood, 1.024 surface and 1.0249 bottom. At last of the ebb the water is sometimes discolored, even to its mouth, by the muddy water from Winyah Bay.

North Inlet separates North Island on the south from De Bordieu Island on the north, and being open to the sea the density of the water is high. Its bottom is composed of shifting sands, which even extend in places up Jones and Town creeks. These conditions render this area unsuitable for the cultivation of oysters.

Jones Creek is the longest and one of the largest of this system of creeks, and flows entirely through the marshes between Muddy Bay and North Inlet. It has two outlets into the bay, its own mouth, and a second through Sign Creek, which is a short branch of Jones Creek and enters Muddy Bay farther to the westward. In the lower or southern part, between its mouth and Divide Creek, the water is too fresh and muddy and the bottom too soft for successful cultivation. The tides meet and divide near Divide Creek, which derives its name from this fact; but the exact point of the division is dependent on the prevailing winds and the freshets in the Peedee River. These conditions affect this part of the creek as they do No Man's Friend Creek, Oyster Bay, and in a lesser degree Sawmill Creek. This is shown at several places where many dead shells and a few live oysters are found. The type of shell is fine, being deep and cup-shaped. These oysters grew during long periods of drought, to be destroyed subsequently by freshets. Nature does all she can here, but man's hand must assist in cutting off the supply of fresh and muddy water, by closing the mouths of Jones and Sign creeks with flood-gates, before oysters can be raised successfully.

To the northward and above Divide Creek there is found an area which corresponds with Sawmill Creek and presents the same conditions and features. Oysters are found there in deep water among many dead shells and much rubbish, covered with barnacles and mussels. The living individuals are poor; the older, having contended against adverse circumstances in a crowded community, have reached old age with sponge-bored shells and covered with barnacles, stunted in growth, and unfit for market. The water is too muddy in this locality to rely with certainty on a catch of spat; the deposit of sediment is constantly going on and would very quickly foul the shells or cultch. In approaching North Inlet the conditions become more favorable, as they do in Town Creek, the greatest obstacle being the quicksands or shifting bottom, which limit the available ground to a small proportion of the entire area.

No oysters are found in deep water in the bed of the stream, except in the locality above mentioned and in those areas of suitable bottom which have been planted; but raccoon oysters are found along both shores. The water at the lower mouth of Jones Creek is practically fresh, both at the surface and at the bottom. Near the mouth of Divide Creek, while in January the specific gravity was 1.0171 surface and 1.0173 bottom, in March the water had become approximately fresh. At the mouth of Duck Creek the specific gravity was 1.0238 surface and 1.0239 bottom; and near its mouth at North Inlet on the last of the flood, 1.0247 surface and 1.0249 bottom.

Old-Man Creek is a short, wide arm which connects Town Creek, through its upper part called Cook Creek, with De Bordieu Creek. The average specific gravity of the water is higher than in the creeks heretofore mentioned, because this creek is nearer to the inlet and is cut off from the main volume of fresh water which pours through Town Creek into North Inlet on the ebb tide, only a part being forced back by the flood tide and finding its way through the side issue of its mouth into Old-Man Creek. The latter ebbs and flows with Town Creek, the divide of the tides taking place in that part of the creek called Cook Creek, which in turn ebbs and flows with De Bordieu Creek. The conditions of the water are thus rendered more favorable, inasmuch as Old-Man Creek is not subject to the rapid and radical changes in density which we have found in other places. It is also less charged with mud in suspension, but the proximity of the inlet and the strong tides give rise generally to an

unsafe bottom of quick and shifting sands, with some soft ground in the coves. At its most northern part, near its junction with Cook Creek, it widens out into a mud flat which is called Sea Creek Bay, and which is studded with patches of small raccoon oysters, left bare by the ebb tide, as are the ledges along the shores. The specific gravity of the water at one-third ebb, in the lower mouth during a period of freshet in the Peedee River, was 1.0166 surface and 1.0194 bottom, and in the mouth of Blythe Creek 1.0198 surface and 1.0197 bottom.

Cook Creek is that part of Old-Man Creek which lies between the mouth of Crab-Hall Creek and De Bordieu Creek. It is a shallow stream whose bed is generally a shifting bottom of quicksands. This evil limits the available ground to a very small area. The usual growth of raccoon oysters is found along the shores, but the few oysters which have dropped away from the ledges into deeper water are taken up as rapidly as they assume a favorable shape and quality.

Blythe Creek heads in the marshes near the mainland, and, flowing in an easterly direction, enters Old-Man Creek about 400 yards north of its mouth. Near its head it embraces a series of marsh islands, and is connected by numerous drains with Crab-Hall Creek, which also heads in the same locality. The greater part of the bottom consists of very soft mud, which, brought down from the flats by the strong ebb tides, is being constantly deposited. Near its mouth a shifting bottom of quicksand is found. No natural oyster beds are found here in deep water.

Crab-Hall Creek rises in the same locality and has the same characteristic features as Blythe Creek, flowing like it in an easterly direction and entering Old-Man Creek at its junction with Cook Creek. Much soft bottom occurs in its upper part and a quicksand bottom near its mouth.

Childrens Creek connects Crab-Hall Creek with De Bordieu Creek and takes a northerly direction between the two. The main part of this creek is a muddy flat, unsuitable for oyster cultivation. A small area near its mouth at Crab-Hall Creek appears favorable.

De Bordieu Creek is the last and most northern of this system, and has the greatest length. It takes its rise near a fresh-water lake in the mainland, and flows in a southerly direction, entering North Inlet below its northern point. Another branch of it heads in the marshes near the head of Crab-Hall Creek. The only bottom found available for oyster planting is below the junction of this branch with the main creek, and lies along both shores near its mouth in narrow strips. A quicksand bottom is the most serious obstacle encountered, as nearly all of the area between the fork and mouth is of this character. Raccoon oysters of a fine type occur along the shores, and where they have fallen below low-water mark and have been allowed to remain long enough to lose their raccoon features, they produce a good marketable oyster. This limited area, however, has been exhausted by overfishing. An examination of the narrow strip of bottom in deeper water adjacent to the ledges occasionally discovers a fine oyster, and shows what might be accomplished in the main body of the creek wherever the bottom is sufficiently stable and hard. The density of the water in this system of creeks or tributaries of North Inlet is necessarily high, having no large source of fresh water like the creeks which flow into it from the southward; the water is therefore not subject to the rapid and radical changes in specific gravity peculiar to the creeks between the South and North inlets. The total area of all the creeks between Muddy Bay and North Inlet is about 1,200 acres; area of suitable oyster ground, about 173 acres.

CONCLUSION.

While the survey described in the foregoing pages was not as detailed or exhaustive as it could have been made had there been more time available for that purpose, yet the results obtained in the areas examined are approximately accurate as well as sufficiently extensive to serve as a basis for the development of oyster-cultural operations. Of the total area surveyed, the natural oyster beds cover only a very small proportion. The proportion of natural oyster ground suitable for the production of marketable oysters is still less, being limited to the narrow space below low tide adjacent to the ledges now occupied in part by the detached raccoon oysters and to a few localities in the deeper water where the density is moderated by the inflow of a sufficient quantity of fresh water. These latter conditions obtain in St. Pierre Creek and New River, as has already been explained.

In order to establish more extensive beds recourse must be had to other bottoms, on which oysters do not occur at present, but which seem suited to the purpose by reason of their firm consistency and their abundant food supply. Owing, however, to the high specific gravity of the water in most places of that character, or to other causes now unknown, it is doubtful if such beds would prove self-sustaining through the natural attachment of the spat to the shells or cultch deposited in the deeper water. While the Georgia oyster-planters, up to the present season, have been unsuccessful in obtaining a set of spat on the shells provided for that purpose, the oysters transplanted by them from the tide ledges to deeper water have prospered in the latter, notwithstanding its high density, and the mortality has been no greater than would be expected from the changed conditions of their environment. It is probable that the South Carolina planters will have to rely, in the stocking of their grounds, upon the raccoon oysters living on the adjacent ledges or in the few other favored spots which have been described. While a rather uniform density, somewhere between 1.014 and 1.018, is considered preferable, oysters are successfully cultivated in water of a much higher density.

The extensive marshes and flats, which compose so large a proportion of the low lands along the coast, probably offer the best advantages for oyster-culture by the construction of tidal ponds somewhat on the principle now resorted to in some parts of Europe. With the natural limitation of oyster growths to the area between tides, this region evidently commends itself to the attention of oyster-growers, who could thus not only control the flooding of their beds but also maintain a close supervision upon their stock. As a rule, the oysters do not attain their best condition in South Carolina until late in the winter and early in the spring. But few persons in the State are now interested in the oyster industry, and the planted area is very small, not amounting, outside of the creeks south of Winyah Bay, to more than about 150 acres.

The principal natural enemies of the oyster which fell under our observation or were called to our attention are the conchs, drumfish, and sheepshead, the first mentioned being the most dreaded by the planters. Starfishes and drills were also seen, but they appear to do little if any damage. All of these natural enemies seem to be chiefly restricted to water of a high density, and none were found in the fresher areas represented by New River and St. Pierre Creek.

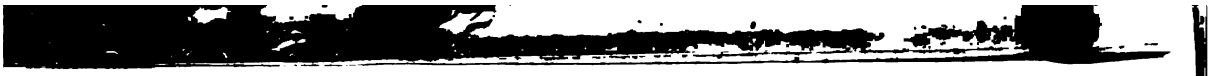
Below is given a table showing the approximate extent of the water territory examined and the approximate area of the natural beds discovered. Probably one-fourth or one-fifth of the total area will be found suitable for oyster planting. The region not surveyed, principally between Breach Inlet and North Inlet, would undoubtedly add a considerable acreage to that enumerated in the table. The season being limited, operations were chiefly directed to those localities which were regarded as of most importance and seemed to present the most favorable conditions. The natural oyster beds are being depleted, as they are in North Carolina and in Georgia, and the only way in which the supply may be maintained or increased is by utilizing for planting the suitable bottoms now producing no oysters. The total area surveyed amounted to about 81,289 acres, and the areas of the natural oyster beds to about 773 acres.

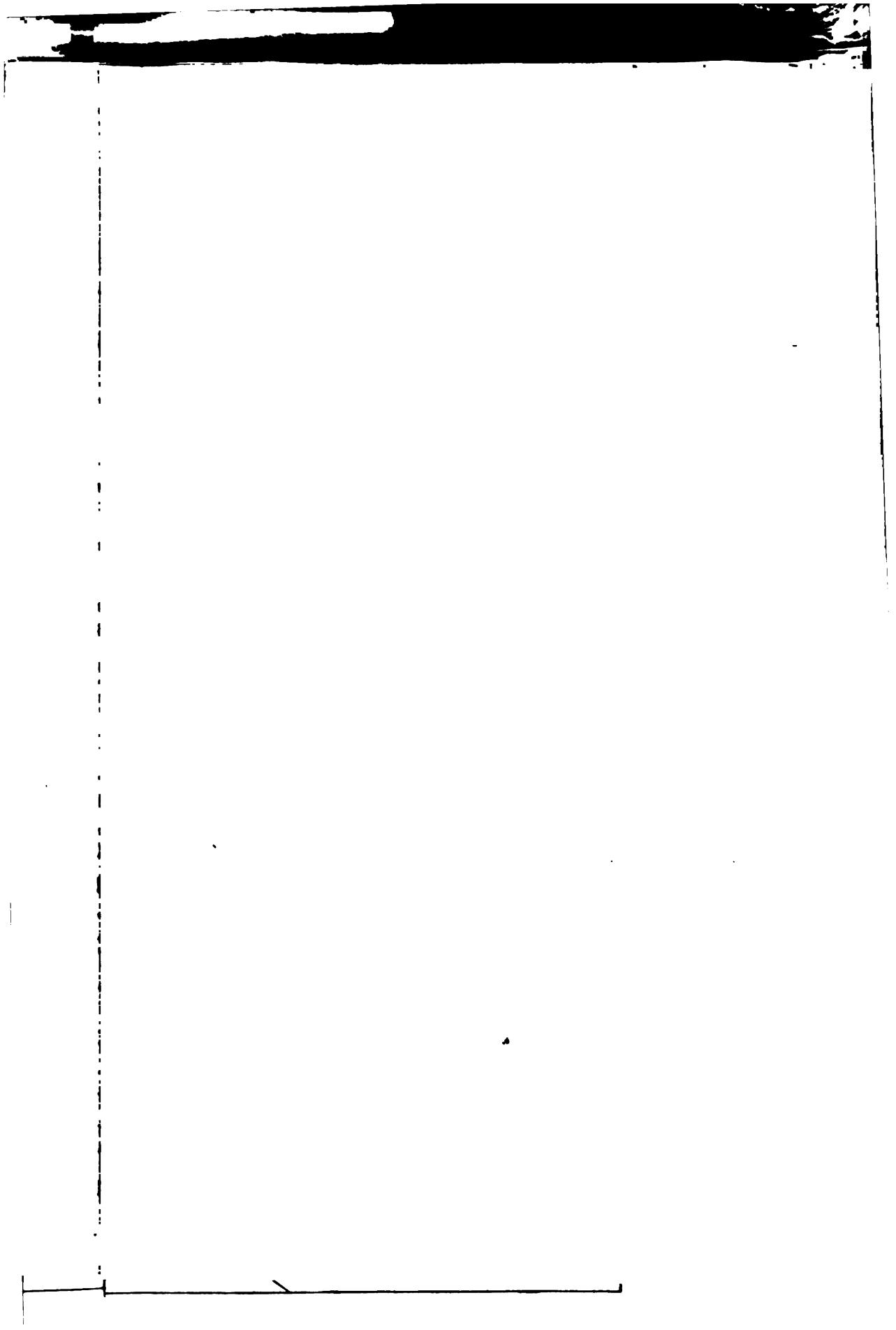
Table of areas examined.

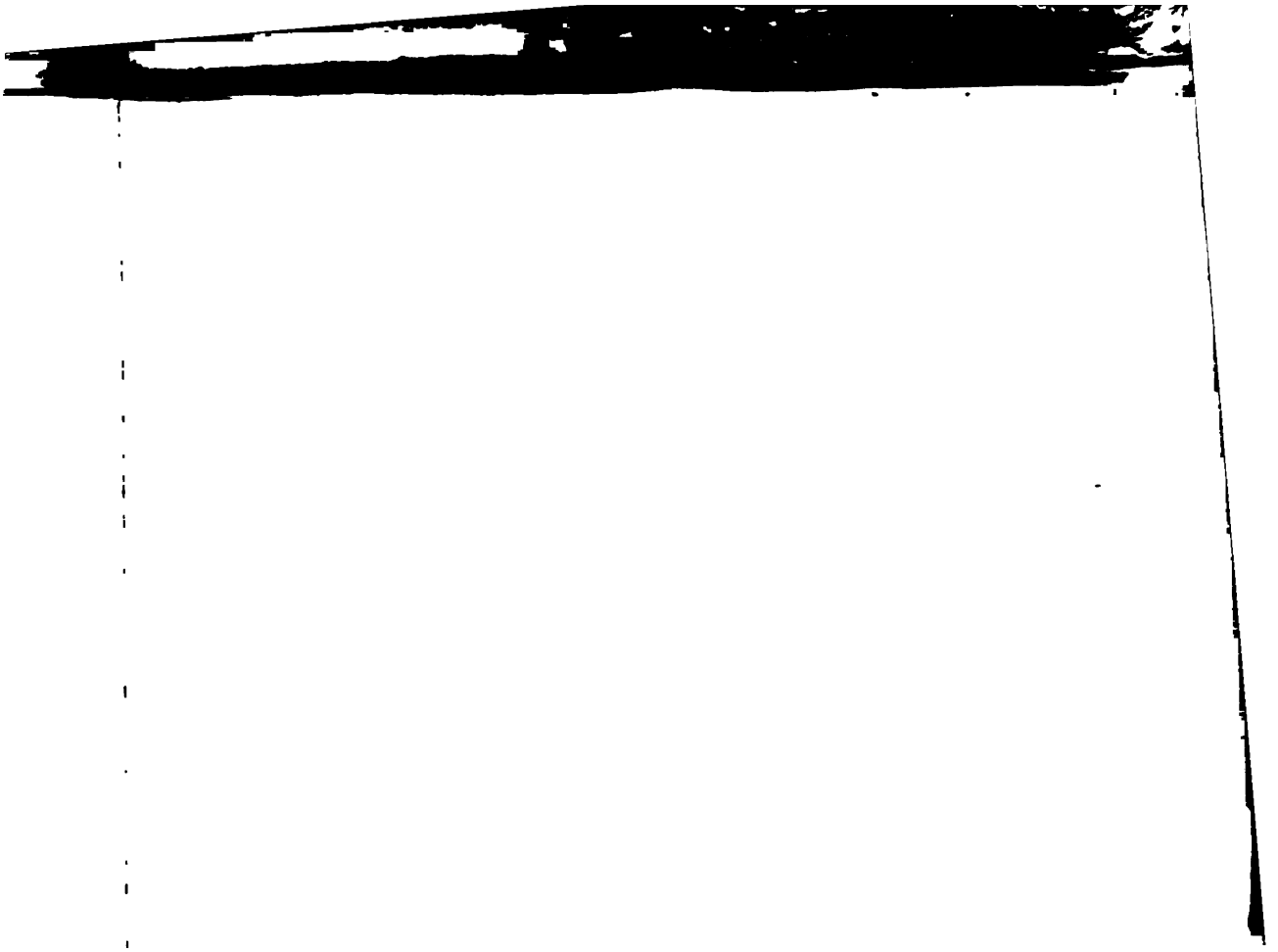
Locality.	Acres.		Locality.	Acres.	
	Total.	Natural oyster beds.		Total.	Natural oyster beds.
New River (part examined)	830	21.4	North Edisto River	2,112	7.9
Cooper River	960	5.4	Bohicket Creek	450	2.2
Calibogue Sound	2,944	*4.8	Leadenwah Creek	384	3.2
Broad Creek	496	6.5	Townsend River	240	.....
May River	2,000	13.1	McCloud Creek	80	.....
Bull Creek	340	7.6	Togodo Creek (part examined)	384	.....
Mackay Creek	904	14.5	Wadmelaw River	2,450	150.5
Skull Creek	720	13.1	Stono River	2,580	14.5
Port Royal Sound	.....	3.6	Kiawah River	900	33.8
Chechessee River	2,810	14.5	Folly River	700	(†)
Colleton River	1,640	12.4	Schooner and Light-house creeks	820	57.5
Okeeteet River	256	2.2	Ashley River (part examined), approximate	2,600	10.4
Broad River	12,274	22.8	Cooper River (part examined), approximate	6,052	10.9
Pocotaligo River	300	3.2	Wando River (part examined), approximate	4,992	34.8
Whale Branch	1,024	11.0	Charleston Harbor	.....	3.8
Archer Creek	150	3.2	Sullivan Island Narrows and tributaries	1,020	7.2
Beaufort River	3,840	19.6	Goat Island Creek	140	5.8
Chowan Creek	720	8.7	Little Goat Island Creek, planted ground, 20 acres	80	.....
Jericho and Battery Creeks	512	9.0	Meeting Reach to Dewees Creek	180	9.6
Brickyard and Albergottie Creeks	560	2.1	Dewees Creek, Grays Bay, Hamline and Copahee sounds	2,500	.....
Coosaw River	7,104	19.6	Inland Passage, between Dewees Creek and Bull Bay	.....	15.5
Parrott Creek	355	4.6	Inland Passage and all the bays and sounds north of it, planted ground, 45 acres	.....	13.3
Dale Creek	290	2.5			
Morgan River	2,496	9.1			
Bull River	928	7.1			
Combahee River	1,088	5.5			
Ashepoo River (part examined)	760	12.0			
St. Helena Sound	.....	4.9			
South Edisto River from Point of Raccoon Island to the mouth	1,150	6.3			
St. Pierre Creek and tributaries	750	42.0			
Bailey Creek, planted ground, 20 acres	80	.....	Total	81,289	773.0
Dawho River (lower part)	334	8.5			
Steamboat Creek and its tributaries, including Mud Flat	1,360	71.0			

* Approximate.

† Not examined.







unsafe bottom of quick and shifting sands, with some soft ground in the coves. At its most northern part, near its junction with Cook Creek, it widens out into a mud flat which is called Sea Creek Bay, and which is studded with patches of small raccoon oysters, left bare by the ebb tide, as are the ledges along the shores. The specific gravity of the water at one-third ebb, in the lower mouth during a period of freshet in the Peedee River, was 1.0166 surface and 1.0194 bottom, and in the mouth of Blythe Creek 1.0198 surface and 1.0197 bottom.

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De Bordieu Creek is the last and most northern of this system, and has the greatest length. It takes its rise near a fresh-water lake in the mainland, and flows in a southerly direction, entering North Inlet below its northern point. Another branch of it heads in the marshes near the head of Crab-Hall Creek. The only bottom found available for oyster planting is below the junction of this branch with the main creek, and lies along both shores near its mouth in narrow strips. A quicksand bottom is the most serious obstacle encountered, as nearly all of the area between the fork and mouth is of this character. Raccoon oysters of a fine type occur along the shores, and where they have fallen below low-water mark and have been allowed to remain long enough to lose their raccoon features, they produce a good marketable oyster. This limited area, however, has been exhausted by overfishing. An examination of the narrow strip of bottom in deeper water adjacent to the ledges occasionally discovers a fine oyster, and shows what might be accomplished in the main body of the creek wherever the bottom is sufficiently stable and hard. The density of the water in this system of creeks or tributaries of North Inlet is necessarily high, having no large source of fresh water like the creeks which flow into it from the southward; the water is therefore not subject to the rapid and radical changes in specific gravity peculiar to the creeks between the South and North inlets. The total area of all the creeks between Muddy Bay and North Inlet is about 1,200 acres; area of suitable oyster ground, about 173 acres.

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In order to establish more extensive beds recourse must be had to other bottoms, on which oysters do not occur at present, but which seem suited to the purpose by reason of their firm consistency and their abundant food supply. Owing, however, to the high specific gravity of the water in most places of that character, or to other causes now unknown, it is doubtful if such beds would prove self-sustaining through the natural attachment of the spat to the shells or cultch deposited in the deeper water. While the Georgia oyster-planters, up to the present season, have been unsuccessful in obtaining a set of spat on the shells provided for that purpose, the oysters transplanted by them from the tide ledges to deeper water have prospered in the latter, notwithstanding its high density, and the mortality has been no greater than would be expected from the changed conditions of their environment. It is probable that the South Carolina planters will have to rely, in the stocking of their grounds, upon the raccoon oysters living on the adjacent ledges or in the few other favored spots which have been described. While a rather uniform density, somewhere between 1.014 and 1.018, is considered preferable, oysters are successfully cultivated in water of a much higher density.

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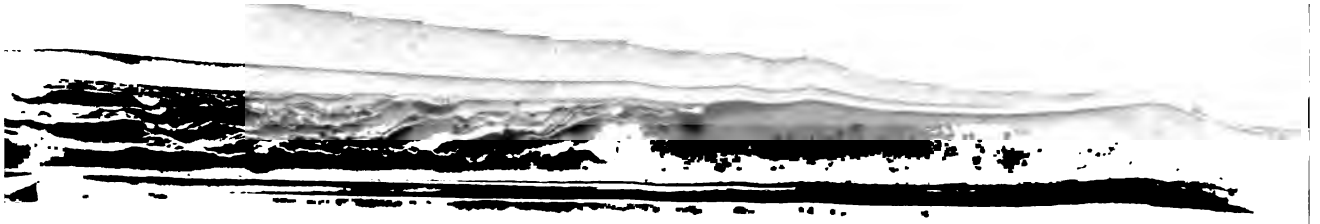
Below is given a table showing the approximate extent of the water territory examined and the approximate area of the natural beds discovered. Probably one-fourth or one-fifth of the total area will be found suitable for oyster planting. The region not surveyed, principally between Breach Inlet and North Inlet, would undoubtedly add a considerable acreage to that enumerated in the table. The season being limited, operations were chiefly directed to those localities which were regarded as of most importance and seemed to present the most favorable conditions. The natural oyster beds are being depleted, as they are in North Carolina and in Georgia, and the only way in which the supply may be maintained or increased is by utilizing for planting the suitable bottoms now producing no oysters. The total area surveyed amounted to about 41,259 acres, and the areas of the natural oyster beds to about 773 acres.

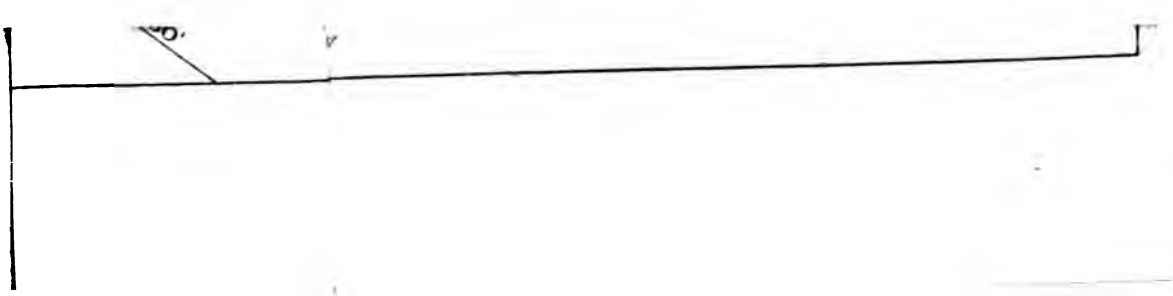
Table of areas examined.

Locality	Acres.		Locality	Acres.	
	Total.	Natural oyster beds.		Total.	Natural oyster beds.
New River part examined	420	27.4	North Edisto River	1,120	7.9
Cooper River	360	7.4	[illegible] Creek	450	2.6
[illegible] Sound	1,800	7.0	[illegible]	200	2.2
Breast Creek	400	4.5	Townsend River	240	
May River	1,000	22.1	[illegible] Creek	80	
Bull Creek	240	7.4	[illegible] Creek part examined	200	
Mackay Creek	800	24.5	Wilmington River	1,450	150.7
[illegible] Creek	720	12.1	Ogeechee River	1,200	14.5
Port Royal Sound		3.4	Kilkenny River	800	22.4
Chechessee River	1,620	24.5	Folly River	700	
Coosaw River	1,600	22.4	Schooner and Clamshoe creeks	450	17.5
Coosaw River	250	2.2	Ashley River part examined, approximate	2,000	30.4
Broad River	12,000	22.4	Cooper River part examined, approximate	6,000	20.0
Pocotaligo River	200	2.2	Wando River part examined, approximate	4,000	24.4
Whale Branch	1,000	11.1	Charleston Harbor		1.0
Archer Creek	150	1.2	Sullivan Island Narrows and tributaries	1,000	7.2
Beaufort River	1,400	20.4	Goat Island Creek	140	5.0
Chowan Creek	750	4.0	Little Goat Island Creek, planted ground, 10 acres	40	
Ferebee and Barnes Creeks	600	9.1	Meeting House Creek	250	9.4
Brickyard and Allegator Creeks	500	2.2	Dewees Creek, Cedar Bay, Hamlins and Isolates islands	2,500	
Coosaw River	7,000	20.4	Inland Passage between Dewees Creek and Bull Bay		15.5
Parrott Creek	1,000	4.4	Inland Passage and all the bays and islands north of it, planted ground, 45 acres		22.2
Dale Creek	1,200	2.5			
Morgan River	2,000	9.1	Total	41,259	773.1
Bull River	1,000	2.2			
Coosahatchie River	1,000	1.1			
Tullifinny River part examined	700	22.1			
St. Helena Sound		4.4			
North Edisto River from Point of Rocks to the mouth	1,150	4.5			
St. Pierre Creek and its tributaries	700	42.1			
Bailey Creek, planted ground, 30 acres	40				
Dawho River, lower part	1,000	4.5			
Steamboat Creek and its tributaries including Mud Flat	1,000	22.4			

* Approximate.

* Not examined.





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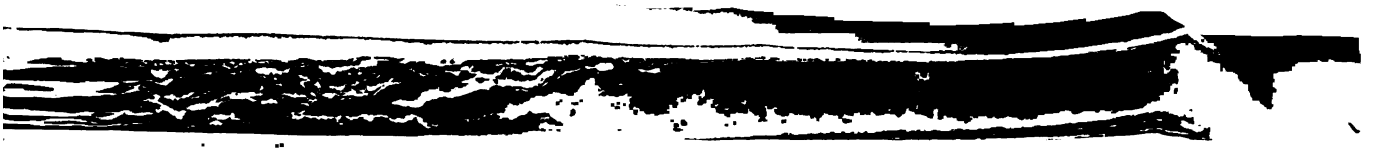
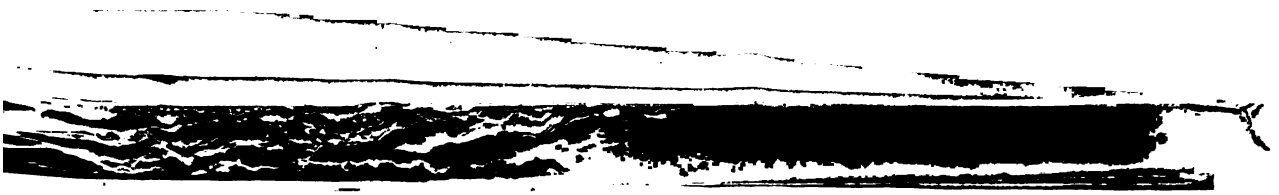




12.—OBSERVATIONS ON THE HATCHING OF THE YELLOW PERCH.

BY S. G. WORTH,
Superintendent of Central Station.

In the month of March, 1889, a number of yellow perch (*Perca flavescens*) spawned in the aquaria at Central Station, and with but very slight attention quite a number of fry were produced. At my suggestion the parent fish had been procured, in the absence of better specimens, to replenish the stock of aquarium fish in anticipation of the throng of visitors at the inauguration ceremonies.

The following year it seemed desirable, in view of possible future wants, to undertake such a systematic series of observations as would furnish full records of the main conditions under which favorable results could be secured; for, however remote the necessity of applying the methods of artificial propagation to this abundant species, the marked simplicity of the spawning habits of the yellow perch seemed alone sufficient to arrest the attention of fish-cultural investigators. Accordingly, with the Commissioner's sanction, 243 ordinary-sized specimens were bought from fishermen at Fort Washington, Maryland, and on February 7, 1890, were conveyed to the tanks at Central Station.

The outlay incident to this study was so inconsiderable, in view of the data obtained and the practical release of nearly a million fry, that the cost should be mentioned. The purchase price of the adult fish, together with the freights and fares incurred in their transfer (that is, all items), amounted to but $15.80.

On the 21st of February 236 specimens, surviving the bruises received in capture, were about equally divided into four glass collector-aquaria of running water, the contents of each aquarium being about thirty-five gallons. Apparently there were 130 females, and these were placed in the aquaria along with about an equal number of males. The water supply was from the city pipes, *i. e.*, from the Potomac, and was then at 44° F. Subsequent changes in temperature are noted farther on, under the table of egg-production.

Thus confined, with but little more water space than a half gallon to each specimen, the parent fish remained from this date throughout the spawning period and here dropped their eggs. Spawning commenced March 10 and ended April 3, eggs being dropped on eighteen days between dates. Nearly all of the eggs were deposited during the night or early in the morning and as soon as observed through the glass

panels they were taken up with a hand net and transferred to universal jars for development. Fertilization was in every case accomplished by the fish themselves and to a degree of perfection that was quite surprising. It was very rare that impregnation failed.

The spawn from a fish consisted of a single free mass, light gray in color, tough and gelatinous. Figs. 1 and 2 accompanying represent the eggs before and after they were spawned. The forked extremity (Fig. 1) represents the anterior or forward end of the roe. After the roe had been spawned and fertilization and water hardness were accomplished its appearance was greatly changed (Fig. 2). On March 19 one of the fertilized and distended lobes of eggs was found to measure 26 inches. On the 20th William Maynard, night watchman, entered on his report: "Found string of eggs from a large perch, measuring 47 inches long by 1¾ inches wide." And again, on the 30th: "Found spawn from a large perch, measuring 7 feet 4 inches long by 4 inches wide at one end and 2 at the other, and weighing 2½ pounds." Continuing, he says: "After the act of spawning the old fish lay on her side for some time as if she would die." "Also found," he says, "that the strings of eggs are like an old-fashioned knitted coin purse, that is, a pocket closed at the ends."

When one of these lobes of eggs was found directly after being spawned the existence of numerous transverse folds allowed the drawing or stretching-out of the mass to many times its original length. After being drawn out and again released it would partially contract and with the hands could be shoved back so nearly into the original compass that it approximately resumed the shape it had previously inside the parent fish (Fig. 1). The arrangement of the transverse folds corresponds in structure to the leather sides of the bellows or accordion. As soon as plumped up by water absorption these numerous folds became so greatly distended as to stand prominently out in rounded curves to meet the surrounding element at every portion of the surface.

Close examination of the egg-lobe revealed the existence of an interior passage throughout its length. The inner cavity was almost entirely closed, being, however, slightly open to outside communication by means of occasional small apertures in the walls. These openings were so unimportant in size and number and of such irregular shape and occurrence that they were at first regarded as accidental. Commissioner McDonald, however, suggested that they formed a part of the system of natural circulation and therefore were probably essential to aëration, and further examination tended to support this view. The egg-lobe was characterized by great springiness, being in fact so highly vibratory that the least agitation of the surrounding water put the whole in motion. This movement evidently forces the water out and in, and hence the apertures seem to be a part of the design, which is a variety of pumping apparatus, for throwing out the stale water and taking in fresh supplies. Whether, in nature, the aërating vibrations are dependent upon the fin-motion of the parents standing sentinel or on external agitation, as the motion from waves or currents, was not determined.

The eggs of the yellow perch are slightly smaller than those of shad, but to make allowance for tissue those under immediate consideration were measured on the shad-egg basis, viz: 28,000 to the liquid quart. The measuring was done the first week in April, some days after the spawning was completed. Practically there was no loss during development and hatching except that brought about voluntarily in examinations. Of the eggs, 91,000, of March 23, were destroyed in making drawings and in

undergoing inspection. The remaining loss occurred among the fry which were held in the aquaria under observation one and two weeks. Probably no other eggs ever handled by the Commission were so hardy as these.

After becoming water-hard the yellow-perch egg-strings are larger than the parent fish. The 88-inch string previously referred to weighed 41 ounces avoirdupois, while the parent fish would not have exceeded 24 ounces previous to spawning. The length and weight of her eggs, as well as the size of the spawning fish, were personally verified by me. The eggs being of less specific gravity occupy relatively more space than the yellow perch themselves.

Table of yellow-perch egg-production at Central Station, Washington, D. C., 1890.

Date.	When deposited or found.	No. of strings of spawn.	No. of eggs.	Water temperature.
				° Fahr.
Mar. 10	11 a. m	1	2,000	44
16	12 midnight	2	15,000	47
17	Night	2	10,000	46
18	8 a. m	2	10,000	45
18	12 midnight to 8 a. m	5	21,000	45
19	2 p. m	2	14,000	45
20	12 midnight to 8 a. m	5	75,000	45
21	....do	5	65,000	45
22	....do	6	80,000	46
23	....do	6	91,000	45
23	....do	6	25,000	45
24	....do	7	15,000	47
25	....do	8	55,000	47
26	....do	5	14,000	47
26	3 p. m	3	37,000	47
27	Night	6	84,000	48
27	....do	1	12,000	48
28	8 a. m	8	100,000	48
29	Night	8	100,000	49
30	....do	4	20,000	48
31	8 a. m	5	21,000	48
Apr. 3	Night	1	90,000	48
	Total	98	956,000	.....

This large yield of eggs was far beyond my most ardent expectations, producing for actual introduction into the streams 754,000 fry. The eggs were developed in twenty-two of the universal hatching jars, their weight being sufficient to keep them well down at the bottoms. No eggs could have been a less care, it being only necessary to prevent them from being enveloped in sediment. This was done by increasing the current at times and keeping them in rapid motion till the mud was washed away. No jar motion was employed in the hatching.

While undergoing hatching the young, as in shad-hatching operations, were automatically separated into the collectors. When any dead eggs were discovered, a rare occurrence, it was usually found that the whole lobe was defective. As the lobe could be removed intact and with one motion of the hand-net, the picking was no trouble whatever. Therefore, in simplicity of manipulation, economy of labor in attendance, and in turning out a large percentage in hatching, the yellow perch may be said to rank at the head of the list.

Four, three, and two weeks were occupied in hatching, the period being modified by temperature. On the 17th of April 754,000 fry were released, 704,000 in the Potomac and 50,000, as an experimental plant, in a private pond near Washington. The parent fish, after all spawning was concluded, were set free again in the Potomac.

It may be said, in conclusion, that with the knowledge gained of the spawning habits of the yellow perch the species might be hatched with success and in indefinite numbers by any person of care in the regions of its abundance. Nothing could be simpler. The operation would consist in storing the adult fish in live-boxes by the middle of March (latitude of Washington, D. C.) and the subsequent daily transfer of the eggs, laid the previous night, to separate compartments to undergo hatching. Beyond being water-tight and tar-coated the hatching vessels would require no further accessories than clean running water and a cheesecloth outlet-strainer, the latter for restraining the premature escape of the fry. Nor is it immoderate to say that it would be practicable, if desirable, for the Fish Commission to hatch 150,000,000 a year at the shad stations on the Potomac, Susquehanna, and Delaware at a cost below $3,000. Two men at either of those stations, sixty days, would amply fulfill the requirements in collecting the adult fish and in hatching out the eggs, while their operations with this species would precede, so as not to interfere with, the regular work with the shad.

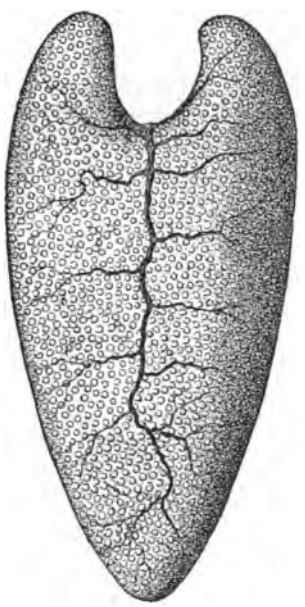


FIG. 1.

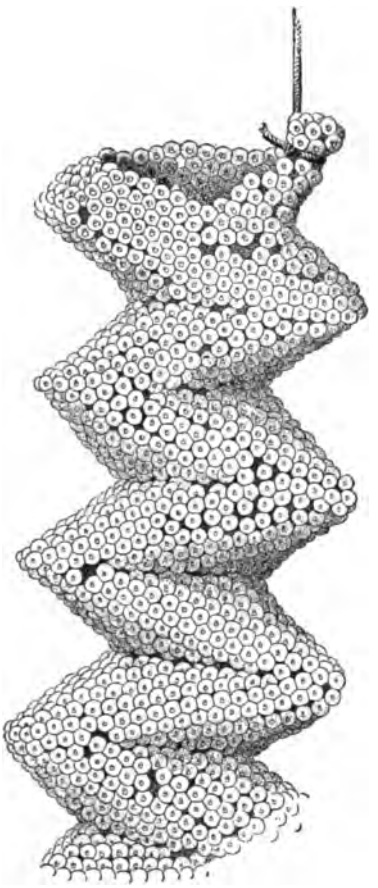


FIG. 2.

13.—THE PHYSICAL AND BIOLOGICAL CHARACTERISTICS OF THE NATURAL OYSTER-GROUNDS OF SOUTH CAROLINA.

BY BASHFORD DEAN.

The following report deals with the character and conditions of the South Carolina oyster-grounds, aiming from their study to point out the natural advantages offered by the State for successful oyster-culture. It is based upon observations and experiments made by the writer while attached as naturalist to the U. S. Fish Commission steamer *Fish Hawk*, during the investigations from December, 1890, to March, 1891. An account of the region examined and maps representing the same will be found in the report of Mr. John D. Battle, entitled, "Report on an Investigation of the Coast Waters of South Carolina with reference to Oyster-Culture."

I.—OYSTER LEDGES AND FLATS.

The entire coast margin of the State, if the immediate ocean shores be excepted, is in the main well provided with natural beds. These, however, are strangely unlike the beds occurring naturally further northward, since in great part they are here found skirting the shore in fringing tidal reefs, living as much of their life in air as in water. Often at low tide the oyster ledges appear to the eye curiously like a low hedge of frosted herbage, grayish-green in color. A nearer view discloses branching clusters or clumps of oysters, densely packed together, whose crowded individuals now become modified or distorted according to their position on the cluster. The individuals that cap the cluster project upward like flat-tipped fingers, slender, narrow, and long, whose shape has given them throughout the South the names "cat tongues," "raccoon paws," or "raccoons." In many localities, as throughout the region of Skull Creek, the raccoon ledges, continuing for ages to encroach upon the stream bed, have formed vast oyster flats, acres, sometimes miles, in extent.

In the stream bed, or, indeed, below the low-water mark, oysters are rarely found, and whenever found are to be regarded as having fallen from the neighboring ledges. As so great a proportion of the State natural beds are raccoon or of raccoon origin, the formation and conditions of these interesting oyster colonies should first be examined.

Ages ago, in South Carolina, the oyster lived under conditions that appear to have been more favorable than those of to-day. There can be but little doubt, from the evidence of shell marls and fossils of the phosphate deposit, that in ancient times there must have been a greater supply of fresh water entering gravel-bottomed bays

and estuaries. The character and volume of these ancient streams must have tempered the sea water and produced the most thrifty conditions for the living of the oyster. In the Pliocene (Miocene?) we here find the fossil shells of myriads of oysters that were decidedly of a brackish-water type, small, single, and thin-shelled, reminding one of the Blue Points of Great South Bay. The shells are rounded, regular in shape and perfect in outline, attesting the peaceful conditions of their ancient life. They show no trace of clustered living.

The natural causes that afterwards destroyed the prosperity of a molluscan age are yet to be ascertained. Certain it is that the incurrent streams were sufficient in force and volume to gully out valley and moor, and to roll seaward from far-distant places the huge fragments of mire-loving animals. It is not until we examine the deep layers of soft, black, river ooze, forming to-day above the phosphate, that we find the first oysters of a raccoon-like type. In the deepest ooze-layers the remains of clustered oysters are few and fragmentary, suggestive of age, transportation, and hard usage. Nearer the shore, and in shallower mud-banks, oysters of all gradations of bunching characters may be found everywhere.

There seems abundant evidence for regarding the living oysters of the State as the survivors of an ostreous golden age, survivors that have struggled successfully against changed and adverse conditions of living. They have become inured to extreme saltness of water, almost that of the sea; they have learned to avoid the submerging mud by growing in clustering masses and by casting anchor along the firm shore-line, often having to build the very land on which to survive. They have learned to live their life as much in air as in water, and in their out-of-water position to endure the cold of winter and the scorching heat of the sun. Even under these hard conditions the oyster's struggle for existence is still an uncertain one. Huge shell banks, miles in length, often 10 feet in height, have been in time formed of raccoon clusters, whose anchorage along the muddy margins has been unstable. A tide unusually strong will roll up and scatter high along the dry beach many bunches of living shells. These are often seen, weeks perhaps out of water, still guarding jealously the few remaining drops of life-giving moisture.

The appearance and formation of raccoon beds may be understood most clearly by referring to the accompanying illustrations of typical natural beds, selected from a series of photographs taken by the writer during the cruise. They represent an oyster ledge (Plate LXII), an oyster flat (Plate LXIII), and an oyster island (Plate LXIV). Plate LXV marks the tidal zone of oyster life, indicated everywhere at lowest tide upon stakes and piling. Plate LXVI shows an extended raccoon-bearing locality.

The oyster ledge* (Plate LXII) is seen from the shore side. The dark-colored shore strip exposed by the receding water shows the limits of high and low tides. In this zone will be seen the living raccoon clusters anchored in the soft mud, some in massive colonies, appearing velvet-like, as in the left of the plate, others scattering, as in the right, anchored less firmly in the soft ooze. The white beach composed of dead shells has for its lower margin the line of high water, a line that is well marked in the picture; this beach, literally a shell heap, rises gently to a firm crest 10 feet above high tide. The size of the shell heap points to its antiquity; many shells are

* Stono River, east shore, 3 miles from mouth, March 6, 1891.

fragmental, water-worn, curiously packed together by ages of water action, often implanted mosaic fashion with shells vertical. A large, dark-colored, living clump is seen prominently on the beach, and smaller clusters are to be noted in a receding dark-dotted line.

The portion of an oyster flat,* shown in Plate LXIII, is seen from the water side. The low, irregular banks of mud are capped with oyster clusters. The sides of the mud banks are extremely soft, engulfing and gradually stifling the raccoon clusters that fall from above. Many of the holes seen in the sides of the mud bank are the gradually disappearing gravestones of buried oysters. The larger holes mark the breathing currents of sinking oysters that are stifling 6 inches below. The entire backbone of the mud bank will be found, by probing, to consist of dead shells around which the mud has gathered. Large living clusters, budding out from the bank, will in time form a peninsula, as seen in the plate. The sink-holes and draining-trenches are naturally of value, preventing the accumulation of mud upon the living raccoons. Marsh grasses encroach very slowly, forming dry land as they go, and limiting by their margin the line of oyster growth.

The oyster island† (Plate LXIV) deserves a passing notice, occurring very often throughout small creeks draining marsh land, extremely noticeable, since nowhere else in the neighborhood are oysters plentiful. It furnishes an interesting example of the oyster's powers of land building. In a region where steep and soft muddy banks have prevented oyster ledges from forming, a single cluster, anchoring on the shore by some chance, gives rise to an outcropping "island," formed entirely of oysters; its framework of dead shells; its flat, dome-like summit bristling with living clusters. The island, accordingly, originating as a cluster attached to the soft bank, continues its growth as a small peninsula and pushes out into the sluggish stream. The stream current aids its formation; its framework is firmly packed with gradually accumulating mud; its growth broadens outward into a portly island of oysters, whose small and narrow peninsula beginnings (where the man in the picture is standing) are almost lost to sight.

That the zone for the attachment of oysters‡ (Plate LXV) is, in South Carolina, between the levels of high and low water may be noted upon stakes and piling everywhere. The maximum size and abundance of oysters, naturally attached, will be seen from the picture to be midway between tide marks. The significance of this zone of oyster attachment is hereafter discussed.

THE OYSTER CLUSTER AND ITS ORIGIN.

Raccoon oysters, in their physical character, as briefly shown, have grown in bunches, clumps, and interlocked colonies, with manifest purpose. To grow in clusters was the oyster's successful expedient in its struggle for survival. Grown in clusters, in the first place, the oyster is less apt to sink in the stifling mud than if separate; the raccoon anchorage, moreover, is apt to be a firm one, at the same time holding the individuals as high up from the mud as possible. Equally important is the function of the cluster in allowing the greatest possible number of oysters to survive in the smallest possible surface space.

* Skull Creek, January 13, 1891.

† May River (Skull Creek Region), 1 mile from mouth of Skull Creek, January 12, 1891.

‡ Sullivan Island, steamboat wharf, March 12, 1891.

II.—OYSTERS DETACHED FROM RACCOON LEDGES.

Throughout the oyster waters of the State there is no question of greater practical importance than that of the general absence of young oysters or spat in the deeper water. Wherever oysters have been found below the level of low tide, as in many of the shallow creeks, they may usually be referred to the neighboring raccoon beds for their accidental origin. Clusters may be seen which are gradually undermined by changing currents, and their progress may later be traced as they slowly roll down a firm shelving bottom into deeper water. Accordingly, we are not surprised to find that "dropped-off" raccoons occur more commonly in marginal waters in scattering irregular beds, rarely in compact masses, and more rarely still in any great number.

That deep-water oysters are generally of raccoon origin seems confirmed also by the absence of spat in their neighborhood.* Whatever may have occasioned the death or absence of oysters in the younger stage, it has certainly been of no serious detriment to the well-being of "dropped-off" raccoons. They appear to have outgrown what is perhaps a disease of infancy, and under their new conditions of getting a livelihood they are greatly changed for the better. The bunching condition in deeper water becomes gradually less marked, the decay of basal shells allowing the individuals to separate. These now begin to lose their raccoon features, and in the end become "single" oysters. As a raccoon, its shell was long, slender, thin, almost to transparentness; its puckered free-edge was knife-like in its sharpness; its body was watery, swollen, and flaccid; its "meat" transparent, showing plainly the contained vessels and viscera; its palps and hood were blistery and distended; its pericardium swollen and atrophied; the edges of its transparent mantle thickened and heavy.† As a single oyster, it proves the benefit of the changed or deep-water conditions of living, and becomes portly, well-fed, and solid, different in every way from its former self. Its shell is now rounded and heavy, blunt at the "nib" and regular in shape. The table oysters of the State, in many instances especially well flavored, are almost entirely of this character.

Nature has thus demonstrated conclusively the simplest method of oyster-culture, how to transmute a tasteless raccoon into a table oyster. It is neither difficult nor costly to scatter in marginal waters about a fathom in depth, where the bottom is suitably firm, the raccoons raked from the neighboring ledge. The time required for the raccoon to acquire the features of single oysters will of necessity vary according to season and locality. The period of "conditioning" may be considerably shortened by separating the clustered oysters before planting, and a few months will probably be found to effect a marked change in the oyster's condition.

* A few exceptions have been noted in the report of Mr. John D. Battle.

† The bettering of the condition of the raccoon oyster during early spring or late winter months has been pointed out by Mr. Battle. The improved feeding conditions which spring offers the exposed oyster may perhaps serve as a strong aid in its struggle for survival, enabling it to reserve nutriment, which later is developed into generative products.

III.—ABSENCE OF OYSTER SPAT IN DEEP WATER.

The shells of exposed oyster ledges are usually well adapted for collecting spat, especially those clusters that immediately fringe the stream. A few feet below the level of low tide the appearance of spat becomes unusual, and still more unusual as the water gradually deepens. The question of why oyster spat is absent in deep water is of practical importance to oyster-culture in this region. To determine the cause would settle definitely the method to be pursued in the collecting of young oysters and thus prevent a possible waste of labor and capital. Some of the more important reasons assigned to this absence of the young in the deeper water are as follows:

(1) The extreme density of the water preventing the swimming embryos from sinking at the fixative stage; a suggestion of Lieut. Robert Platt, U. S. N., commanding the steamer *Fish Hawk*.

(2) The extreme softness and film-covered character of the bottom preventing the oyster from fixing.

(3) The suspension of slowly depositing silt in the deeper water, whose clogging action is fatal to the delicate respiration of the microscopic young.

(4) Changes in the composition of the oyster-bed water, either in its salts or food constituents, at different levels.

If the view of Lieut. Platt be established, the process of spat-collecting will be a simple one for the culturist. If the silt and mud theories be correct, the importance of establishing the relation of the size of the seed to be planted successfully to the character of the bottom is a vital one. If the water variations at different depths are at all marked, showing that oyster food is greatest in amount near the shore in shallow water, and that there, too, occur the best conditions of saltness and liminess of the water, a valuable suggestion is gained. It will likewise be of value to determine whether all or some of these possible causes act in concert.

1. Density of water preventing oyster fry from settling.—It can be shown most clearly that South Carolina oysters, living in a water density of 1.017 to 1.024 specific gravity, occur only on raccoon reefs between the extremes of high and low water marks. At low water it is interesting to note how clearly the stakes and piling define this oyster belt, as we have seen in Plate LXV. The region of mid-tide mark shows the greatest luxuriance of growth; the oysters decrease gradually in size and number above and below, becoming straggling and finally disappearing. Occasionally, as the pile is eaten by teredos, the oysters drop to the bottom and become of the "dropped-off" raccoon type. If the proposition be proven that the embryo at the fixative stage can not sink in water of high density, but must form raccoon ledges, some corollaries must naturally follow:

(1) Spat should in no instance be found in deep water of high specific gravity.

(2) As the water becomes fresher, the oysters, with spat of undeniably recent attachment, as in the North, should be found in favorable localities covering the bottom; and, accordingly,

(3) As the water becomes less salt the raccoon ledges should gradually and entirely disappear.

Of course, the only indisputable proof would be to fertilize eggs, carry the embryos as far as possible into the swimming stage, and by actual experiment show that the

floating powers of the young become more marked as the saltness of the water increases. The experiment would not be an impracticable one, for fresh water specimens might easily be arranged in a set of graduated densities by the addition of natural salt. Should it be shown, for example, that in water of 1.023 oyster fry would occur only at the surface, and that in water of 1.016 the young might be found pervading equally the water volume, there could be little doubt of the value of the view of gravity fixation. Circumstantially, however, many opposing facts render this view untenable as long as positive proof is wanting.

(*a*) Spat has been sparingly found affixed to deep-water shells, but we must admit that it may have been attached before the host itself dropped into deeper water.

(*b*) The second corollary certainly does not maintain. Notwithstanding the water becomes fresher in character, deep beds of single oysters do not become common in an increasing ratio. Such as are found rarely have spat attached, and in every way appear still to represent the dropped-off raccoons.

(*c*) As the water becomes less dense, raccoon ledges do not disappear. Oyster ledges occur in Winyaw Bay, where the specific gravity of the water is as low as 1.010.

(*d*) It is well known that a deep set forms naturally in some regions, as about Long Island, New York, where the specific gravity in some places is as high as 1.021; and, moreover, I have recently examined in Florida oyster rocks well covered with spat in water of a density of 1.025 and at a depth of 10 feet.

Again, granting an unexpectedly delicate osmotic character to the young, it may be shown that, if the embryo float, it must keep at surface level; for as the specific gravity of the water is often the same at top and bottom, the embryo, if it sink a few inches, might equally well sink many feet. Heavy barges of the Coosaw Phosphate Mining Co. never draw less than a foot, yet their bottoms are bristling with oysters.

2. The view that the swimming embryo is unable to effect a successful fixation in the deeper waters, on account of the slime-covered character of the bottom and the softness of the muddy bank, might readily be true of many localities examined. The stream bed of many water-courses is formed of the softest and lightest muddy ooze, into which an object, such as an oyster shell dropped as a collector, would unfailingly pass, sometimes to a depth of many feet, as experiments have shown near Port Royal. This ooze layer is widespread in the larger river basins; its extent and character render oyster-culture in its immediate neighborhood almost impracticable; it covers the river phospate rock with a layer sometimes 15 feet in thickness. There have been, doubtless, many cases where oyster-culture has been discouraged by the absolute failure of plants made upon an insecure or shifting bottom. It is evident that the more surface the planted oyster can expose to the soft bottom, or, in other words, the larger and lighter the oyster, the more apt is it to survive, although its efforts in that direction are not apt to improve its commercial quality. A number of specimens have been retained, showing how skillfully mud masses have been plastered into the oyster shell, forming, indeed, an intricate series of mud galleries honeycombing the shell. The general truth of this view as affecting bottom set is of course untenable, as is proved by the oyster-bearing piles. There are, moreover, many localities where the cleanliness of the bottom will compare favorably with that of the best grounds of the Long Island coast.

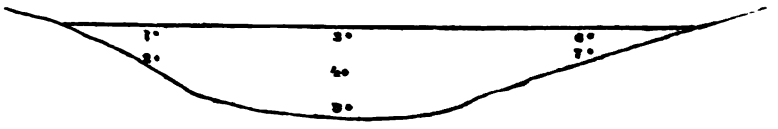
3. The suggestion as to amount of silt carried in suspension, especially in deeper water, should be carefully considered. We must bear in mind the extreme delicacy

of the breathing arrangements of the young oyster, as pointed out by Prof. John A. Ryder, and it is to be remembered that injury to the young caused by silt-bearing water was the cause of the failure of the most careful experiments upon the artificial propagation of the oyster.

Along the South Carolina coast the question of silt suspension becomes of very great interest in the light of geology. Formations are here found (phosphate rock, marls, and fish-bone beds) that in richness of fossils and in extent are curiously unique. For ages the coast regions within the limits of South Carolina must have been a collecting basin or sink, receiving the washed-out drainings of hundreds of square miles. That the fresh waters of the State are still carrying seaward an amount of silt greater perhaps than occurs elsewhere to the north or south, great enough, indeed, to stifle frail microscopic oysters, is therefore in no way remarkable; that flats and shoals are changing and forming constantly and rapidly in rivers and river mouths by the gradual settling of the heavier sediment is abundantly proven.

In the water, at the surface, middle, and bottom, at every locality examined, there is present, in a more or less marked way, a heavy sediment, although the water itself has appeared clear. This sediment is exceedingly fine, in the surface water often requiring three days to settle. So very gradually is it deposited that the living organisms in the water will seldom be thrown down and included in it. It consists of the microscopic particles of clay and silica and, to my surprise, of the fossil tests and fragments of tests of the diatoms of the Ashley group. The occurrence of these fossils is, however, under the circumstances a very natural one. My attention was first called to the recurrence of numbers of dead shells of *Coscinodiscus radiatus*, for which I was at a loss to account. This form I remembered occurred fossil, as well as recent, and the finding in this genus of *radiolatus* and *granulatus* and many other well-known forms confirmed my decision. It is evident that the amount of this impalpable sediment may vary greatly from natural causes, and the variation in the turbidity of river water is sometimes quite remarkable. There can be little doubt that this silt is injurious to the young oyster, and its presence in quantity may readily suffice to account for the entire absence of oyster spat in deep water. The greater the volume of the water mass, the greater would, of course, be the amount of suspended silt; the nearer the surface the less silt, and conversely.

The amount of silt in a given specimen may readily be determined with a fair degree of accuracy, but it is impossible to learn whether the results obtained are relatively great or small, since I can find no standard of comparison. However, I give in brief the results of the following experiments. A stream section across the Ashley, just



below the drawbridge, was selected.* Specimens of water were taken on March 11 from midstream and on the margins, in a fathom of water, at the points numbered in the diagram. Five hundred cubic centimeters of each specimen were shaken and carefully filtered, and the filtrate then dried and weighed. The weight doubled gave the weight of sediment per liter.

* Beds of raccoon oysters are abundant there.

The following were the results:

Locality.	Sediment (grams per liter).
Surface:	
1. West bank	0.70
3. Midstream	.75
6. East bank	.72
Deeper:	
2. West bank	1.00
4. Midstream	1.00
5. Midstream, bottom	1:60
7. East bank	1.40

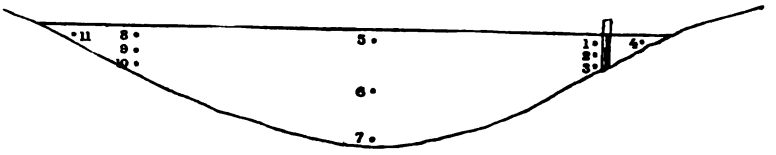
It is noteworthy that the greater proportion of the sediment is present in midstream, where oyster set does not occur, and that the minimum amount of sediment occurs at the marginal surface, where the oyster ledges are found. The exposure to air of these tidal reefs allows the sediment to dry and possibly gives the oyster an opportunity to expel any ingested mud. My notebook states that the sediment from the marginal water is "extremely oily, clogging the fine filter paper, rendering the filtering process an extremely slow one. The filtrate leaves a waxlike smear near the point of the paper funnel."

Enough has probably been said in this connection to show the necessity in practical oyster-culture of collecting spat on floating collectors and of allowing it to attain before planting a considerable size, the larger the better. To plant successfully, the oysters should certainly be not less than 2 inches in diameter. The necessity of an unshifting and fairly solid bottom is of course obvious. If the collecting surface be a horizontal one, the under side will be found to collect the greatest amount of spat. This condition was found to occur in all of the natural floating collections examined. Barge bottoms as successful collectors have already been noted. All phosphate barges have yearly to be scraped of their compact, densely crowded set, the oysters within this time thriving remarkably, specimens 3 inches in length having been taken the present season (February, 1891) from the barges of the Coosaw Mining Company.* In this position the young oysters are in water bearing evidently the minimum amount of silt, and, from their down-turned position, least affected by the gradual depositing of sediment.

4. The question as to variations in the composition of water at different depths tending to be of benefit to marginal oysters has proven a comparatively unimportant one. Marginal surface waters do not differ in composition materially from those deep in midstream, and therefore can offer no remarkable inducement to the formation of raccoon ledges. They are neither remarkably fresher nor richer in lime for shell building; they offer no conditions of far greater abundance of food or greater freedom from impurities that might account for the absence of oysters in deep water. Neither do the tides appear to bring about any strikingly beneficial changes in the character of marginal waters.

* Dr. C. Bunting Colson: "History of the Mill-Pond Oyster and Cause of its Disappearance"; Proc. Elliott Society, March, 1888.

With a view to the examination of these questions, analyses were made of water specimens collected at such points as to represent the entire section of a stream. Thus, in the accompanying diagram, representing a theoretical stream section, water specimens would be collected by means of the water cup at each of the positions numbered 1 to 11. A set of specimens, thus representing the character of the cross section of the stream, would be collected at the half tides and at high and low tide. The collection and analyses of specimens would be so arranged that, in point of time, the comparison of tides might be as accurate as possible.



For a more complete comparison three sets of such examinations were made at different localities; one, near Beaufort, South Carolina, of a typical river mouth with deep water; a second, of a neighboring shallow, oyster-bearing stream; and, finally, a similar section over the raccoon beds of the Ashley River in the neighborhood of Charleston. The variations in the results, as seen in the appended tables (pp. 357–361), were too slight to be of practical importance. Comparative study shows, however, that changes in water layers do occur, changes that if more marked would tend to favor somewhat the growth of marginal rather than of ledge oysters, thus:

(*a*) Saltness, as a rule, slightly increases with the depth of water. There appears, however, to occur (a foot or two below the surface) a stratum slightly salter than the water immediately above or below it. Extreme marginal waters are least salt, having per gallon about $\frac{1}{200}$ in weight less of chlorides than in deep water.

(*b*) Carbonates (lime) increase with the depth of water.

(*c*) The amount of salty and limy ingredients are, in the localities examined, but little affected by the changes of tides.

(*d*) The greatest amount of decaying organic matter appears to be carried in the deeper midstream. The water is there most impure at low tide and purest at high water. The extreme marginal waters show a noticeable increase of impurities, evidently from surface drainage.

(*e*) The most noteworthy variation shown by the analytic study will be seen in the organic element of the water, representing in general oyster food. The greatest amount appears almost invariably to occur in marginal waters near, and a fathom or two below, low-water mark. In the South Carolina waters examined the marginal waters appear (probably from the character of the bottom, higher temperature, and less rapid current) to afford the best conditions for the attachment and rapid increase of minute plant life. As nearly as the organic results can be determined, it would appear, with due allowance, that marginal waters contain double the amount of oyster food found in midstream. Tides appear to have but a slight effect upon increasing or diminishing the amount of oyster food. The best feeding conditions of the water are during the rising of the tide, which appears to carry shoreward from the deeper waters a number of pelagic forms. High tide contains the next highest percentage of oyster food. The poorest feeding conditions are shown at low water.

IV.—GENERAL CHARACTER OF THE BOTTOM AND ITS LIFE.

If we exclude the mud layer that has been referred to as often forming the stream basins throughout the State, the character of the bottom adapting it for oyster-culture is in no way remarkable. Hard mud, sandy, shelly, or coarse gravelly bottoms occur in more or less extended tracts in all the waters of the State—a practical question that has already been discussed in the topographical report.* In these favored tracts plant and animal life are extremely abundant and every condition is favorable for the growth and reproduction of the food of the oyster. Some small tracts will be found covered with a low growth of red seaweeds, whose fronds, teeming with minute organisms, are the natural nurseries of the oyster's food. These seaweed localities may usually be regarded as among the best of places for oyster-planting, especially where rapid fattening is desired; since, as a rule, they mark the most beneficial conditions of bottom, current, warmth of water, and feeding.

V.—THE FOOD OF THE SOUTH CAROLINA OYSTER.

Success in oyster-culture depends to a very great extent upon the feeding conditions that the oyster can obtain. The French culturists have long shown that oysters, like fowls, should be well fed if they are to be marketed. They have demonstrated in the use of the still pond (*claire*), how to provide the best conditions for a profusion of food organisms as the surest aid to the rapid and tasteful conditioning of the oyster. The *claire* is shown to be a marine hotbed for the minute plants preyed upon by the oyster. It is a pond, shallow and well warmed, almost currentless, whose salt water is kept uniformly tempered by fresh streams, whose bottom is so disposed that sediment, otherwise often fatal, will deposit naturally in trenches, and not over the prolific beds of oyster-food organisms. It has been shown that, under favorable conditions of feeding and living, an oyster may become of marketable size and quality in one-third of the time required under its natural (*i. e.*, undomesticated) conditions. Undomesticated oysters are accordingly dependent to a large degree for their thriftiness upon the amount of food their natural surroundings afford.

In the United States but little attention has yet been directed to examining the food conditions offered by different localities as a natural aid to oyster-culture. We are apt to look upon all salt waters as offering far and wide the same essential feeding conditions. We forget that streams in different regions differ widely in their water composition, rate of current, shallowness, and warmth, and that thus one, favorably circumstanced, might far surpass its neighbors in its general fitness for oyster-culture.

In the studies of the Carolina waters it has therefore been deemed important not merely to state the natural characters of the oyster-bearing waters, but also to compare, as carefully as possible, the general and especially the feeding conditions of all the localities of the State examined. Comparisons of value might then be drawn with the natural conditions known to maintain in profitable northern oyster grounds.

* An investigation of the coast waters of South Carolina with reference to oyster-culture. By John D. Battle. Bull. U. S. Fish Commission, 1890, pp. 303-330.

In discussing the question of South Carolina oyster food in its many aspects, the general character should first be examined. The oyster, it is well known, is quite an epicure in its feeding, preying almost entirely upon the minute, lowly organized plants that float or swim in its neighborhood. With shell slightly opened, and with the dark-colored sensory margins of its mantle protruding, it draws into its shell a narrowing, food-bearing water current. At once it draws in the current, carefully screens out the minute food particles, and passes out a stream of filtered water. It avoids, if possible, ingesting sand or mud.

The food organisms are readily taken for examination from the oyster's stomach. The tip of the soft body of the oyster is removed by a single clip of the scissors, and a pointed pipette is introduced at once into the stomach cavity, and the fluid contents, rich golden-brown in color, are drawn up. The stomach contents of a number of oysters from the same locality may be taken and put in labeled homeopathic vials, from which a number of dippings of both sediment and fluid should at once be examined.

Oyster food, it will be found, consists mainly of diatoms, a particular kind of minute, lowly organized plant, that have the remarkable power of moving freely about in the water. Unlike any other plants, they are incased in a pair of saucer-like glassy shells, fitted one to the other like the lid to a pill box. These delicate shells are the natural prey of every microscopist. He admires their varied shapes (round, S-like, elliptical, or three-cornered) and tests his lenses upon the delicate pits, ridges, and traceries shown in their glassy structure. A photomicrograph (Plate LXVII, Fig. 1) shows the delicate basket-work markings of a cleaned shell of a *Surirella gemma*, a diatom not uncommon in Carolina oyster stomachs. The glassy cases of the minute plants appear in no way to inconvenience the oyster's digestion. The mucilaginous sheathing that encases prominently many diatoms is first dissolved, and the digestive juices find their way through the intricate glassy valves, speedily attacking and reducing the jelly-like contents, together with the inclosed golden-brown pigment pellets. The emptied diatoms appear to settle gradually, and are soon brushed by countless cilia from the stomach to the intestine.

The food organisms of the Chesapeake oyster are given by Prof. Ryder in the report of the Maryland Fish Commission for 1881, p. 20. The food of the Long Island oyster is discussed by the writer in the report of the New York Oyster Investigation, 1886. In the latter paper was noted the extreme importance of the plant element of oyster food, examination showing that about 90 per cent of the ingested organisms were diatoms. The animals ingested were few in number, and sometimes unwelcome.

In South Carolina the elements of the oyster food are practically those of Long Island. The proportion of its component organisms may thus be generally stated:

	Per cent.
1. *Animal life*—(*a*) Crustaceans, (*b*) worms, (*c*) protozoans	5
2. *Vegetable*—(*a*) Diatoms	90
(*b*) Fragments and reproductive bodies of seaweeds	2
(*c*) Pine pollen	3

ANIMAL ELEMENT OF OYSTER FOOD.

(*a*) *Crustaceans* are uncommon, even the more minute entomostracans. Fragments of a copepod were twice noted, but were of so large a size (antennæ, meral plates, and leg segments), that they were probably ingested piecemeal, together with unwelcome mud and sand. This view is apparently confirmed by the presence in the same stomach of such out-of-the-way articles of diet as the antennæ of the sand fly (*Chironomus*) and bunches of cells of pine and palmetto. Eggs of shrimp-like forms have occasionally been noted.

(*b*) *Vermes.* Eggs of annelids have been found, but nothing rotifer-like.

(*c*) *Protozoans* constitute the main animal element of oyster food. In some localities, where there occurs a direct ingress of the ocean waters, numbers of *Foraminifera* are occasionally found, *Polystomella*, *Textilaria*, and *Rotalia* being the prominent types. But many of these were probably stirred up by some unusual action of the water. Oysters from a well-examined locality, after a heavy rain, showed a large proportion of *Foraminifera*, many dead shells among them. The monothalamian rhizopods, *Arcella* and *Euglypha*, are abundant in several localities. Infusorians are uncommon. But few bell animalcules were found throughout the season, even in the stomachs of those oysters that harbored *Pinnotheres*. A number of the ciliates were noted, especially *Trachelius*. In almost every specimen would be found, separate, however, numbers of a small gregarine, a monocyst, perhaps in a young stage. Parasitic *Opalina* is also not uncommon.

Spicules may finally be mentioned as among the valueless animal relics found in the oyster stomach. These in a cleaned condition are given off in myriads by the disintegration of sponges, mainly *Cliona*, and of gorgonian corals, and have been ingested while in process of settling.

PLANT ELEMENT OF OYSTER FOOD.

(*a*) *Diatoms.*—The diatoms taken from the oyster offer a rich field for the student in rare forms and variety of species. Many of the diatoms named in the New York report as the food of the Long Island oyster have been found to occur in the Carolinian oyster. In the southern oyster the greater saltness of the water is at once apparent in the richness of many forms of food regarded as exclusively marine, as *Triceratium favus* and several *Triceratia*, apparently undescribed, that I have seen from the Caribbean Sea. The lack of brackish-water diatoms affords a marked contrast to the Long Island forms. In the present connection it would hardly be of value to give the list of even those which I have been able to identify. The diatoms of the Carolina waters have never been thoroughly studied systematically, and there are very many, especially of *Cymbella*, *Navicula*, and *Nitzschia*, that are probably undescribed.

The bulk of the diatoms consisted of minute species of elongated forms. The prominent genera represented were *Navicula* (*didyma* E., a very common species), *Amphora*, *Cymbella*, *Pleurosigma* (*littorale* W. Sm., a prominent species), *Synedra*, *Grammatophora*, *Surirella* (*limosa* Bai. and *gemma* E., prominent), and a number of species of *Amphipleura*. Of the rounded forms, three species were common in every locality examined, *Cyclotella rotula*, *Coscinodiscus radiatus*, and *Actinocyclus undulatus*. The following genera occur prominently but sparingly throughout the State: *Triceratium*, *Biddulphia*, *Stephanopyxis*, and *Cerataulus*.

In the North the bulk of the food appears to be mainly the larger (and therefore more nutritious) *Melosiræ* and kindred forms that occur often in ribbons and exhibit little activity in the water. The southern oyster from his forced altitude must needs put up with the smallest and most active of diatoms.

(*b*) *Fragments and reproductive bodies of seaweeds.*—Broken-off bits of seaweeds are very uncommon. Not a fragment of ulva was noted, and scarcely a bit of the more delicate red seaweeds. Occasionally will be found a slender, spindle-shaped resting cell of one of the *Œdogonia*. Zoöspores may sometimes be noted. The little wriggling nematoid-like *Spirillum bryozoon*, Pritchard, has in some instances been found abundant. Later in the season oogonia of many forms will probably be found, as they are in the North.

(*c*) *Pine pollen.*—Pollen of the cone-bearers has been found in stomachs from every locality examined (December to April), sometimes extremely abundant. It is undoubtedly in early spring an important food element, a unique one, certainly. Of the enormous amount of pollen scattered in "sulphur showers" in so rich a pine region as Carolina, a large part finds its way into the water, floats for a day or two, and is appropriated in part by the ledge oysters as the tide rises. Another part becomes water-soaked and is ingested by the oysters of lower depths. The abundance of pollen may be noted not merely on the deck of the vessel, but even in sulphur eddies in the stream itself, as prominently shown in Parrott Creek.

That this extraordinary food is of nutritive value is apparent in the changes in color and shape that the pollen grains undergo, caused without doubt by the process of digestion. In many instances where the protoplasmic contents of the granule have been dissolved out the outer corky layer of the cell wall ruptures in irregular fissures. With this fortuitous food supply so early in the year, the oyster can prepare for early spawning. The total amount of food, moreover, is by this increment rendered more uniform during spring and summer, the increase of diatoms in summer tending to compensate for the loss of pollen.

AMOUNT OF OYSTER FOOD OCCURRING IN SOUTH CAROLINA WATERS, AS DETERMINED BY ANALYSIS.

It is of value in examining the oyster-bed water of a new locality to be able to compare its food-bearing character with that of a well-known oyster-ground as a standard, *e. g.*, Great South Bay, Long Island (Blue Point), or the north side of Long Island, as shown in the New York Report of 1886. A comparison of fair accuracy may be made by means of water analysis. The test of a large number of South Carolina localities will be found appended.

In determining the food value of a given water specimen the following method,* in brief, was adopted. A couple of liters of water were taken by means of the water cup from a foot above the bottom, aiming thereby to obtain a fair specimen of the oyster's living medium. The specimen could not well be taken nearer the bottom on account of the risk of including the loose organic matter resting there, which would not normally be included in the food of the oyster. If carefully collected, the water specimen when examined in the laboratory would, as a rule, be found to be free of floating organic impurities. Such a specimen would now be agitated vigorously and allowed

* The bacterio-quantitative method was early tried for this work, but was found unreliable.

several minutes to settle. The living organisms upon which the oyster might feed do not meanwhile descend to form a part of the slight sediment. The volume of water necessary for organic analysis may now be carefully drawn up in a pipette thrust well into the jar. The specimen represents the average prevalence of oyster food in the given locality, and, if properly collected, it may be proven by the microscope to be free practically from the organic matters which should not be included in the food of the oyster.

The Wancklin method of determining the albuminoid ammonia is then followed. With skillful handling this method is certainly an accurate one, the Nessler color test readily determining the presence of $\frac{1}{1000}$ of a part of ammonia in 1,000,000 parts of water. The free ammonia given off when the water is merely boiled, must be considered as representing ammoniacal salts, derived in great part from disintegrated tissue, and marks the impurity of the water. The solid organic matter in the water, which we will have to allow is mainly oyster food, is thus left coagulated. A strong caustic now introduced destroys this organic residue, and the product of combustion is quantitatively determined as albuminoid ammonia. That the amount of albuminoid ammonia in uncontaminated salt water will (with due biological precautions) represent the quantity of organisms present must be conceded. In the present work this method was followed for lack of a better one.

Referring to the albuminoid ammonia results in the table of analyses, we may get some general idea of the food character of the water, as well as of local differences. We may see, for example, the general uniformity in the albuminoid constituents, averaging perhaps about $\frac{1}{100}$ parts per 1,000,000 in almost every locality in the State. This amount is certainly not as great as that shown in the oyster-grounds of the north side of Long Island; but, on the other hand, its uniformity in food constituents must make it at least a more than fair feeding-ground. In a general way the waters of the north side of Long Island are a third richer in their feeding constituents than those of South Carolina, while Great South Bay* (Blue Point), which is practically a huge "claire" built by nature on French principles of oyster-culture, is thrice richer.

The effect of tide and depth of water upon the total amount of oyster food in a given locality has already been described.

The general appearance of some of the typical organisms from the stomach contents of the South Carolina oyster has been outlined in Plate LXVII, Fig. 2, which represents the objects as magnified about 225 diameters. Nos. 1 to 20 are common forms of diatoms.

* In this connection it is to be noted that brackish waters (sp. gr. 1.010 to 1.012) are apparently richest in oyster food. The studies of the Great South Bay, for example, whose density is kept uniformly low (1.010 to 1.013) by the entrance of a number of small, fresh, sluggish streams, show the presence of the greatest profusion of diatoms, both in number and species. In American oyster-culture the time is not far distant when oyster ponds of this favorable character will be employed for preparing oysters for market. In introducing the French systems, however, careful studies are yet to be given the questions of compensation of labor and of altered conditions of locality.

TIME OF FEEDING OF THE OYSTER.

The question of the time of feeding of the oyster will be an interesting one in the management of culture ponds. Here the ingress of water can be definitely regulated by tides day or night, to suit the feeding habits of the oyster. That the rising tide is the dining time of the oyster has usually been conceded; how far feeding activity is governed by daylight or darkness is, however, a question of interest. The results of the following examinations are noteworthy.

In a favorable locality* three gatherings of twenty oysters each were made, all from the same station, at 7:20 a. m., 1 and 5:30 p. m. Care was taken to select oysters in every way similar in size and character, freedom from oyster-crabs, bryozoans, or sponges. The stomach contents were taken within half an hour after the time of collection. The total quantity of food in process of digestion at these times of day could then be crudely compared. To determine comparatively the richness or quality of food contents of each set of specimens, a simple color test was devised. The total food-bulks were placed in separate Nessler glasses (15 cubic centimeters, slender), and to the two darker fluids distilled water was carefully added until the three specimens, viewed from above, were of the same color. The volumes in each tube, now of about the same nutritive value, were readily measured and compared. The following are the results:†

Time of day.	Color.	Amount in cubic centimeters of contents of 20 stomachs.	Food contents of 20 stomachs rendered of the same nutritive value and their bulks compared (cubic centimeters).	Time.	Tide.	Depth.	Water temperature.	Water, sp. gr.	Remarks.
						Feet.			
Morning..	Pale watery ..	.5	.5	7.20	¾ flood ..	20	60	1.0225	Weather, foggy; bottom, packed shells.
Noon	Rich greenish-brown.	2.5	12.5	1.00	¼ ebb	12	60	1.0239	Weather, bright; bottom, sponges, bryozoans.
Night.....	Light ocherous	1.5	5.0	5.30	Low	8	60	1.0225	Weather, clear; bottom, red seaweeds.

It is noteworthy that during the night the oysters had been practically foodless; that, although the tide had well risen in the morning as late as 7:20, the oysters had fed but little; that the bulk of ingested food was taken during the strongest daylight, morning and afternoon. This suggestion, as to the feeding habits of the oyster, is not a surprising one when we remember that it is during the strongest sunlight that diatoms, as plants keenly sensitive to the sun, are most active and are known to migrate in floating clouds from bottom to surface.

* Myrtle Bush Creek, near Port Royal, February 10, 1891; a fine bed of "dropped-off" raccoons.

† The accompanying conditions of water are given in the table of analyses, p. 359, Nos. 108–110.

VI.—MESSMATES AND ENEMIES; SPAWNING SEASON.

THE OYSTER CRAB AND ITS RELATION TO ITS HOST.

The oyster crab as a messmate has doubtless been the subject of comment from prehistoric times. Pliny quaintly speaks of it as a discreet doorkeeper, who, in return for safe quarters, pinches the oyster, warning it to close its shell in time of need; while Plutarch, as if unwilling to be outdone by his voluminous rival, ascribes the commensalism to motives of partnership, the crab contributing his eyesight, the oyster his entrapping shell. Small fish, sadly deluded and captured, are feasted upon. Prof. Verrill has noted that it is the female only that takes refuge within the oyster's shell. Prof. Ryder has added to its interest by showing that to its body are attached clusters of bell-animalcules (*Zoöthamnium*), whose progeny are of food value to the oyster, and that in turn even the bell-animalcules pay toll to the common host in the broken-off vibriones that infest them. He accordingly regards the crab as a food nursery whose presence is of benefit to the oyster.*

In the Carolina waters excellent opportunity is offered for the study of the oyster crab. It was often found in as many as 5 per cent of the oysters opened. All individuals were apparently of one species, *Pinnotheres ostreum*, Say; more than one female was never noted infesting a single oyster. In most instances the crab is found well thrust in between the palps, usually between the middle ones. Occupation at this position is evidently annoying to the oyster, for the palps sometimes show thickened outgrowths, or are malformed and stunted in size.

That the crab is of value to the oyster as a purveyor or as a nursery for food appears (from many notes that have been made) extremely doubtful. It must be admitted on the one hand that, in almost every instance, *Zoöthamnium* colonies have been found in every variety of position and abundance. As a rule, however, the clusters are small and infrequent. In position they are usually moored to the crab's basal leg segments. In the matter of food there can be no doubt that the crab secures many of the small crustaceans which are not normally the oyster's prey. But on the other hand, the stomach contents of the crab consist in great part of the minute organisms, diatoms, pine pollen, zoöspores, and infusorians, sought by the host. And as the closest examination of the oyster's stomach failed in every case to show the presence of the bell-animalcule or its swarmers, as a compensatory food tribute, the benefits derived by the oyster from a tenant that can not be ejected appear somewhat doubtful. The crab will be found to crowd itself snugly between the oyster's palps, where food organisms are constantly collecting, and at this point may readily help itself to a selfish share of the incoming food.

The hairs of leg tips and mouth parts of the messmate are curiously specialized for arresting the slime-coated patches of oyster food. At the distal end of the dactylopodite the stout recurved hairs are most numerous, holding, as may actually be seen, as if with the teeth of a rake, the slime-entangled masses of organisms. The slender

* Ryder, Maryland Fish Commission, 1881, p. 24.

hairs of the mouth parts, notably of maxillæ, are disposed in rows like the teeth of a comb, and are apparently of service in carding out the arrested food supply. In most instances the crab is found with the carapace toward the left valve; the legs on the side of the oyster's mouth are straightened out, those of its right side flexed. In this position the recurved leg hairs may serve admirably to entangle the food. This process of impaling the food patches upon the spike-like leg hairs may even be rendered more complete by the brushing action of neighboring cilia of the oyster.

THE ENEMIES OF THE OYSTER.

The oyster-planter in South Carolina will fortunately have but few natural enemies to deal with. Starfishes and drills (*Urosalpinx*), the dreads of the northern culturist, rarely occur; nor do the larger whelks and periwinkles appear to be dangerously plentiful. At all events, the out-of-water character of the majority of the natural beds would render them in a very slight degree subject to these enemies. Below the mark of low water the boring sponge (*Cliona*) is occasionally abundant. Some localities that offer naturally the most admirable conditions for oyster-culture are rendered practically useless by the greatest profusion of sponges. All the oysters that can here be tonged are sadly impoverished; their entire energies have been directed to cementing over the mouths of galleries that are continually piercing the lining of the shell. Many infested shells are coarsely granulated upon their inner faces, and may readily be crumbled between the fingers. Curious malformations in shell occur when the tormented mollusk has had to form a new hinge or new plates for the attachment of the muscle. In fresher and muddier waters the dropped-off raccoons sometimes become covered with barnacles (*Balanus*), being in some instances literally encumbered with them.

THE SPAWNING SEASON.

Dr. C. Bunting Colson, of Charleston, who has carefully studied the raccoon oyster, states* that the spawning season extends from the middle of March to the middle of August. Oysters with ripened ovaries were noted in the shallow creeks of Winyaw Bay on January 10. Spawning oysters were taken near Charleston in February. Individuals appear to differ widely in the time of their spawning, although taken from the same station. In some cases a portion of the reproductive lobes appears to be far more mature than the remainder. It is probable that cases of intermittent spawning occur throughout almost the entire year whenever favorable conditions of temperature prevail. To determine the season at which set occurs some interesting notes may be made from the oyster-covered bottoms of phosphate barges. These are drawn from the water, at stated times for necessary repairs, and the oysters thoroughly removed. A barge bottom thus shows, for example, in February, spat one-sixteenth to one-eighth of an inch in diameter, occurring not uncommonly upon oysters 2½ inches long, that were certainly not older than the launching of the barge in September.

* Elliott Society, March, 1888, p. 199.

VIII.—EFFECT OF PHOSPHATE DREDGING UPON THE OYSTER WATERS.

It has been claimed that dredging for phosphate rock, one of the most important industries of the State, pollutes the waters and renders whole regions totally unfit for oyster-culture, and it seems natural that the extent of the industry would exercise some effect upon the life of neighboring waters. In the Coosaw River, for example, a dozen dredgers in the space of 3 miles collect daily about 1,000 tons of washed phosphate rock. This continued work might affect the neighboring water in two ways: 1 chemically, by causing substances, gases, acids, or salts that have been imprisoned in rock or marl to be taken into solution by the water; or 2 mechanically, by churning or creating a marked muddiness of the water, the material in suspension becoming gradually deposited wherever carried by the currents.

In the first case, to determine any noteworthy chemical changes, a number of water specimens were specially collected; several from the neighborhood of dredgers on either side of Coosaw River, one at the mouth of Parrot Creek, and all of bottom water. The following are the results:

1 That the salty constituents of the water appear in no way abnormal.

2 That the ammonias are increased in a marked way, doubtless from the churned-up organic matters which may at once be detected by the microscope, perhaps in part from the dissolved salts of the marl or phosphates. The free ammonia in the immediate neighborhood of dredgers shows as great a proportion as [illegible] parts per 1,000,000, ten times as great an amount as shown at Port Royal. This ammoniated condition of the water can hardly be regarded as of serious danger to neighboring life.

3 That the phosphoric ingredient of the water exists in so slight a degree as to be altogether innocuous. No better biological proof is needed that the presence of large gorgonias, sponges, and bryozoans anchored to the fragments of the phosphate rock itself. Water from the neighborhood of Coosaw Dredge No. 7* shows [illegible] parts per 1,000 of phosphoric acid, the highest result obtained. Off the mouth of Dale Creek, about half a mile distant, the phosphoric acid contained is but [illegible] parts per 1,000. The alkaline ingredients of the water render impossible the presence of phosphoric acid in an unprecipitated condition, save perhaps as a trace. The amount of phosphate present, slight as it is, is doubtless due to the suspended particles of the phosphate rock. Chemically, therefore, the neighboring waters are not dangerously polluted by the dredging of phosphate.

The injury that would befall life in the neighborhood of dredging is due almost entirely to the mechanical formation and deposit of sediment. The murkiness of the water, the heavy character of the fine, gray silt, and the continual current shiftings of bottom are the causes that render the entire neighborhood for miles about practically unfit for oyster-culture. Particular note was made in the shallow water of the character of the depositing sediment and of the entire absence of living oysters. The daily amount of waste sand, mud, and marl that is sifted out into the stream by the washing processes is almost incalculable. One great dredger, for example, before reaching the phosphate rock, cuts through a dozen feet of overlying material.

* Then in Coosaw River, 1 mile above the mouth of Parrot Creek, 100 yards from right shore

IX.—GENERAL SUMMARY.

In the foregoing notes a number of suggestions have been deduced relating to oyster-culture in the State of South Carolina. We may, for example, infer:

(1) That marketable single oysters may be cultivated in the neighborhood of oyster ledges in all shallow streams whose bottom is sufficiently firm to bear up the weight of the shells and sufficiently unshifting to prevent their engulfment. To establish in any particular locality the suitable character of the bottom, experiments may readily be made.

(2) That the supply of seed oysters may be obtained at once and in great plenty from raccoon ledges and flats. That the oysters should, if possible, be separated from the cluster with due regard to character and size. That the size of the raccoon "seed" should be at least that of a silver dollar, to enable it to resist the invasion of mud and the silt-bearing character of the water. That the seed, although sadly impoverished in its raccoon condition, will in time become changed decidedly for the better in size and quality. That the time required to render the oysters of a marketable quality will depend upon the feeding and living conditions of the locality, and upon the care with which the seed clusters have been separated. A single season, judging from the growth of oysters of a known age (attached to phosphate barges) would probably be sufficient to render the oyster of marketable value.

(3) That if spat is to be collected for purposes of culture, the use of floating collectors of any design is preferable. The down-turned faces of the collector prove most valuable by reason of the lack of sediment accumulation. The destruction by teredos of floating collectors made of scraps of wood or bark suitably disposed, will allow the seed oysters to be planted gradually and automatically.

(4) That to plant, in deeper water, clean shells as spat-collectors would in this region be futile. This result will prove true in waters apparently free from silt.

(5) That marginal waters from the level of low tide to about a fathom in depth will be found best suited for oyster-culture. In this zone the oyster will no longer be exposed to the hardship of raccoon life. If the bottom is favorable, it will here be least subjected to accumulating silt and will receive the most favorable conditions of temperature and feeding.

In conclusion, I desire to express my thanks to those who have so kindly aided me throughout my studies. To Lieut. Robert Platt and the officers of the *Fish Hawk* and to my associates I am indebted for very many courtesies extended to me during the winter. To Dr. C. Bunting Colson, of Charleston, my thanks are due for many valuable notes upon oyster-culture in South Carolina.

Daily record of quality of South Carolina water—an outline—Continued.

Day	Month	Year	Locality	Weather	Temperature of water	Time	Depth (feet).	Specific gravity (at normal).	Incrustation (salt grains per gallon).	Total solids (grains per gallon).	Chlorine (grains per gallon).	Ammonia, parts per million.		Remarks.
												Free.	Albuminoid.	
6	Nov.	4	Beaufort River at Beaufort wharf.	Clear	64	1	S	1.0225	1.429	1.785	7.1	0.110	0.182	
6		4	Port Royal, off place of railroad wharf.	do	64	1	S	1.0225	1.429	1.785	7.15	.0840	.0880	
6		4	do	do	64	1	S	1.0225	1.429	1.785	7.2	.0840	.0880	
6		4	do	do	64	1	S	1.0225	1.429	1.785	7.2	.0840	.0880	
6		4	Broad River, at Coosaw River	do	64	1	S	1.0225	1.429	1.785	7.2	.0720	.0760	Water black; muddy.
6		4	Beaufort River, 2 miles above mouth.	do	64	1	S	1.0225	1.429	1.785	7.2	.0880	.0920	Water black; muddy; black deposit; sediment.
6		6	Port Royal, mouth, portion at railroad wharf.	Foggy	63	1	S	1.0225	1.429	1.785	7.1	.110	.160	Water cloudy; muddy; sediment.
6		6	do	do	63	1	Bot.	1.0225	1.429	1.785	7.1	.112	.152	Do.
6		6	do	do	63	1	Bot. 15	1.0225	1.429	1.785	7.1	.112	.152	Do.
6		6	do	do	63	1	.5	1.0225	1.429	1.785	7.1	.0960	.1360	Water cloudy; sediment.
6		6	do	do	63	1	Mid.	1.0225	1.429	1.785	7.1	.0960	.1360	Do.
6		6	do	do	63	1	Bot. 15	1.0225	1.429	1.785	7.1	.0960	.1360	Do.
6		6	do	do	63	1	.5	1.0225	1.429	1.785	7.1	.0960	.1360	Water cloudy; sediment.
6		6	do	do	63	1	Bot.	1.0225	1.429	1.785	7.1	.0960	.1360	Do.
6		6	do	do	63	1	Bot. 15	1.0225	1.429	1.785	7.1	.0960	.1360	Do.
6		6	do	do	63	1	.5	1.0225	1.429	1.785	7.1	.0960	.1360	Do.
6		6	do	Cloudy	63	1	S	1.0225	1.429	1.785	7.1	.0960	.1360	Water cloudy; sediment.
6		6	do	do	63	2	S	1.0225	1.429	1.785	7.1	.0960	.1360	Do.
6		6	do	do	63	2	Bot.	1.0225	1.429	1.785	7.1	.0960	.1360	Do.
6		6	do	do	63	2	Bot. 15	1.0225	1.429	1.785	7.1	.0960	.1360	Do.
6		6	do	do	63	2	.5	1.0225	1.429	1.785	7.1	.0960	.1360	Do

Table of analyses of South Carolina oyster-bed waters—Continued.

No.	Date.	Locality.	Weather.	Temperature of water.	Tide.	Depth (feet).	Specific gravity (corrected).	Chlorides (salt) (grains per gallon).	Total solids (grains per gallon).	Carbonates (grains per gallon).	Ammonia, parts per million.		Remarks.
											Free.	Albuminoid.	
	1891.												
74	Feb. 4	Jericho Creek, section of stream at Brotherhood's wharf.	Clear ...	58	½ F	Bot. 14	1.0221	2,436	2,790	7.5	.0200	.1060	Midstream.
75	4	.....do.....	...do....	59	½ F	1	1.022	2,408	2,703	7.3	.005	.1018	Near west bank.
76	4	.....do.....	...do....	58.5	½ F	Bot. 13	1.022	2,446	2,740	7.4	.002	.1119	20 yards off west bank.
77	4	.....do.....	...do....	57.5	½ F	2	1.0221	2,401	2,709	7.3	.0113	.1075	Near east shore (under piles).
78	5	.....do.....	...do....	55.5	L	.5	1.0223	2,346	2,783	7.55	.002	.1181	East shore, at outer pile.
79	5	.....do.....	...do....	55	L	Mid.	1.0225	2,430	.....	7.85	.0039	.1304	Do.
80	5	.....do.....	...do....	55	L	Bot. 12	1.0225	2,458	.....	8	.0081	.1206	Do.
81	5	.....do.....	...do....	55.5	L	.5	1.0222	2,418	2,738	7.75	.0113	.0875	Midstream.
82	5	.....do.....	...do....	55	L	Mid.	1.0222	2,418	.....	7.8	.004	.100	Do.
83	5	.....do.....	...do....	55.5	L	Bot. 14	1.0221	2,419	2,745	7.9	.0045	.070	Do.
84	5	.....do.....	...do....	58	L	1	1.0225	2,412	.....	7.4	.006	.108	Near west shore.
85	5	.....do.....	...do....	55	L	Bot. 9	1.022	2,408	.....	7.6	.005	.110	20 yards off west shore.
86	5	.....do.....	...do....	56	L	1	1.0224	2,380	.....	7.3	.010	.117	Near east shore.
87	6	.....do.....	...d0....	54.5	½ E	.5	1.0227	2,446	2,788	7.6	.0033	.1115	East shore, outer pile.
88	6	.....do.....	...do....	54.5	½ E	Mid.	1.0225	2,474	2,790	7.7	.0033	.1233	Do.
89	6	.....do.....	...do....	54.5	½ E	Bot. 16	1.0225	2,508	2,800	7.7	.004	.0955	Do.
90	6	.....do.....	...do....	54.5	½ E	.5	1.0225	2,452	2,801	7.6	.0013	.1205	Midstream.
91	6	.....do.....	...do....	54.5	½ E	Mid.	1.0227	2,464	.....	7.75	.0021	.1310	Do.
92	6	.....do.....	...do....	54.5	½ E	Bot. 12	1.0227	2,502	2,809	7.8	.0003	.0905	Do.
93	6	.....do.....	...do....	54.5	½ E	1	1.0225	2,452	.....	7.5	.0221	.116	Near west shore.
94	6	.....do.....	...do....	54.5	½ E	Bot. 9	1.0225	2,458	.....	7.7	.0228	.101	20 yards off west shore.
95	6	.....do.....	...do....	54.5	½ E	.5	1.0225	2,458	.....	7.4	.0220	.099	Near east shore.
96	9	.....do.....	...do....	59.5	H	.5	1.0221	2,464	.....	7.3	.003	.150	East shore, outer pile.
97	9	.....do.....	...do....	58	H	Mid.	1.0222	2,488	.....	7.4	.004	.160	Do.
98	9	.....do.....	...do....	58	H	Bot. 21	1.0227	2,490	.....	7.5	.006	.161	Do.
99	9	.....do.....	...do....	57.5	H	.5	1.0226	2,464	2,788	7.3	.034	.155	Midstream.
100	9	.....do.....	...do....	58	H	Mid.	1.0226	2,486	.....	7.7	.033	.150	Do.
101	9	.....do.....	...do....	57.5	H	Bot. 17	1.0226	2,486	.....	7.8	.020	.145	Do.
102	9	.....do.....	...do....	59.5	H	1	1.0221	2,402	2,758	7.25	.....	.....	Near west shore.
103	9	.....do.....	...do....	58	H	Bot. 16	1.0226	2,440	2,767	6.9	.....	.....	20 yards off west shore.
104	9	.....do.....	...do....	58.5	H	.5	1.023	2,460	.....	6.9	.021	.....	Near east shore.
105	5	Myrtle Creek, 1 mile above Brotherhood's.	...do....	54	L	5	1.0221	2,408	2,730	7.2	.0013	.0615	Best of oysters, running into stream bed; bottom hard; mud and gravel.
106	5	.....do.....	...do....	53.5	L	Mid.	1.0222	2,270	.....	7.35	.00065	.104	
107	5	.....do.....	...do....	55	L	Bot. 12	1.0222	2,380	2,770	7.45	.00065	.0865	
108	9	.....do.....	Foggy ...	58.5	H	.5	1.0228	2,424	2,778	7.5	.0118	.0915	Specimens taken at same time as those of analyses 96 to 104.
109	9	.....do.....	...do....	58.5	H	Mid.	1.0228	2,444	2,797	7.7	.0046	.1165	
110	9	.....do.....	...do....	59	H	Bot. 18	1.0227	2,464	2,798	7.5	.0046	.0830	
111	17	Coosaw River, near red buoy 6..	Clear ...	64	½ F	Hard 10	1.0189	2,234	2,686	7.2	.080	.120	
112	17	Coosaw River, at ferry.....	...do....	64	L	Soft 18	1.0197	2,251	2,650	7.	.063	.120	Gray silicious and clayey sediment. Microscopic particles of organic substances included, mainly fragments of moss and marsh grass. Many tests of fossil diatoms sometimes occur.
113	17	Coosaw River, off mouth of Dale Creek.	...do....	64	L	16	1.0211	2,234	2,620	6.9	.0665	.110	
114	17	Coosaw River, off mouth of Parrott Creek.	...do....	64	½ F	Soft 16	1.0199	2,076	2,686	6.8	.1180	.160	
115	19	Coosaw River, east shore opposite mouth of Dale Creek.	...do....	65	½ E	Soft 10	1.0198	2,006	2,528	7.1	.0499	.2325	
116	19	Coosaw River, off mouth of Little Chenken Creek.	...do....	66	½ E	Soft 11	1.0132	1,484	1,732	5.4	.0566	.2675	

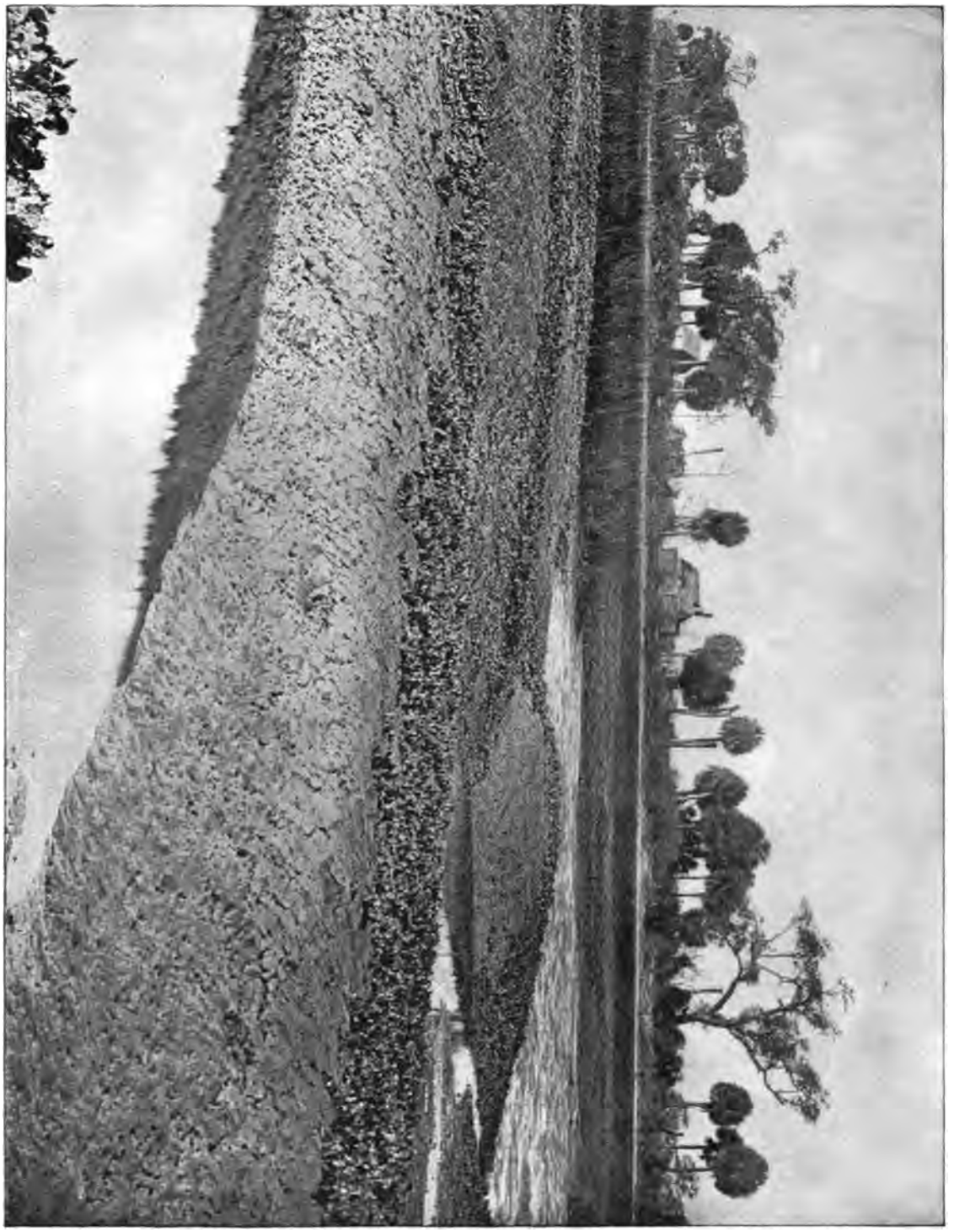
Table of analyses of South Carolina oyster-bed waters—Continued.

No.	Date.	Locality.	Weather.	Temperature of water.	Tide.	Depth (feet).	Specific gravity (corrected).	Chlorides (salt) (grains per gallon).	Total solids (grains per gallon).	Carbonates (grains per gallon).	Ammonia, parts per million. Free.	Ammonia, parts per million. Albuminoid.	Remarks.
	1891.												
117	Feb. 19	Coosaw River, inside mouth of Bull River.	Clear ...	64.5	½ E	Soft 22	1.018	1,964	2,286	6.4	.0432	.170	Sediment less notable; organic fragments, profusion of diatoms.
118	18	Coosaw River, ½ mile south of mouth of Bull River.	...do	65	½ E	Soft 17	1.0198	2,184	2,620	6.5	.053	.1625	
119	19	Combahee River, within mouth, off west bank.	...do	64	½ E	Hard 1	1.0179	1,908	.....	5.95	.040	.162	Heavy clayey sediment; living forms, decaying plant tissues; odor marshy.
120	19	South Wimbee, 2½ miles above mouth.	...do	67	L	Hard 12	1.0184	2,004	.....	6.4	.039	.159	Very little sediment; organisms mainly living.
121	24	St. Helena Sound, 300 yards off southeast end of Morgan Island.	...do	66	½ E	Hard 30	1.0206	2,282	2,555	7.45	.0332	.1575	After wind storm, siliceous sediment; living organisms plentiful; fossil diatom tests.
122	24	Morgan River, inside mouth of Village Creek.	.. do	62.5	½ F	Hard 11	1.0207	2,186	2,620	7.05	.0266	.15	
123	25	Ashepoo River, 1½ miles above mouth (Mosquito Creek).	...do ...	66	½ E	Hard 14	1.0128	1,400	1,602	6.15	.0199	.2275	Water slightly cloudy; flocculent dark sediment, clayey, with many organic particles.
124	25	Ashepoo River, near mouth.....	..do .	64	½ E	Hard 24	1.0231	2,446	2,674	7.65	.0133	.1325	Slight ocherous sediment, decaying organisms absent.
125	Mar. 2	McCloud Creek, 2½ miles above mouth.	Windy	57	H	Hard 10	1.0194	2,228	2,608	6.9	0466	.140	
126	3	Wadmelaw River, near mouth	Clear	56	½ F	Hard 23	1.0196	2,152	. .	6.6	.0533	.1335	
127	4	Steamboat Creek, opposite Edisto landing.	Cloudy	56	L	Hard 25	1.0202	2,177	2,346	6.7	.0466	.1375	
128	4	North Edisto opposite mouth of Leadenwah Creek	do	57	L	Hard 40	1.0219	2,382	2,620	7.35	.0399	.1425	
129	4	North Edisto opposite mouth of Bohicket Creek	..do	57.5	½ F	Hard 18	1.0228	2,418	2,701	7.4	0466	1320	
130	4	North Edisto opposite mouth Townsend River.	do	56	½ F	Hard 60	1.0233	2,300	2,691	7.6	0133	.1220	
131	4	North Edisto, in mouth of Bohicket Creek	Clear	56.5	½ F	Hard 11	1.0228	2,412	2,801	7	.0133	1217	
132	6	Stono River west branch, 3 miles above mouth of Kiawah River	do	54	½ E	Hard 20	1.0237	2,582	2,084	8	0172	125	
133	6	Stono River, over mud flats of Kiawah River	do .	54.5	½ F	Hard 11	1.0242	2,020	2,900	7 95			
134	6	Stono River, 1 mile above mouth.	...do ...	56	½ E	Hard 18	1.0236	2,480	2,820	7.8	0006	.1115	
135	8	Cooper River, section of stream from custom house dock	..do ..	60	H	.5	1.0221	2,408	2,028	7.95	0019	080	At custom-house bulkhead.
136	8	.....do	do ...	56	H	Mid.	1.0221	2,412	2,024	8.05	0014	095	Do
137	8	..... do	do ..	55.5	H	Bot. 10, soft	1.0221	2,430	2,701	8.05	0013	115	Do
138	8	.. do	do .	55	H	.5	1.0221	2,424	2,650	7 4	.0014	.085	Midstream, black buoy.
139	8	.... do	. do .	55	H	Mid.	1 0221	2,480	2,018	7.5	0008	.115	Do.
140	8	.....do ....do ...		55	H	Bot. 36	1.0222	2,430	2,700	7.9	.0054	.105	(Cloudy sediment, clayey and siliceous.)
141	8	..... do ....do		56.5	H	Mud .5	1.0222	2,408	.. ..	7.5	.0046	.130	East shore at stake, over raccoons.
142	8	... do ....do		56.5	H	Bot. 6	1.0222	2,424	.....	7.6	.0026	.100	Do.
143	9	Ashley River, stream section at Charleston bridge.	...do	59	H	.5	1.0227	2,357	.....	7.45	0039	.140	E. bank; v. p. 342 for notes.

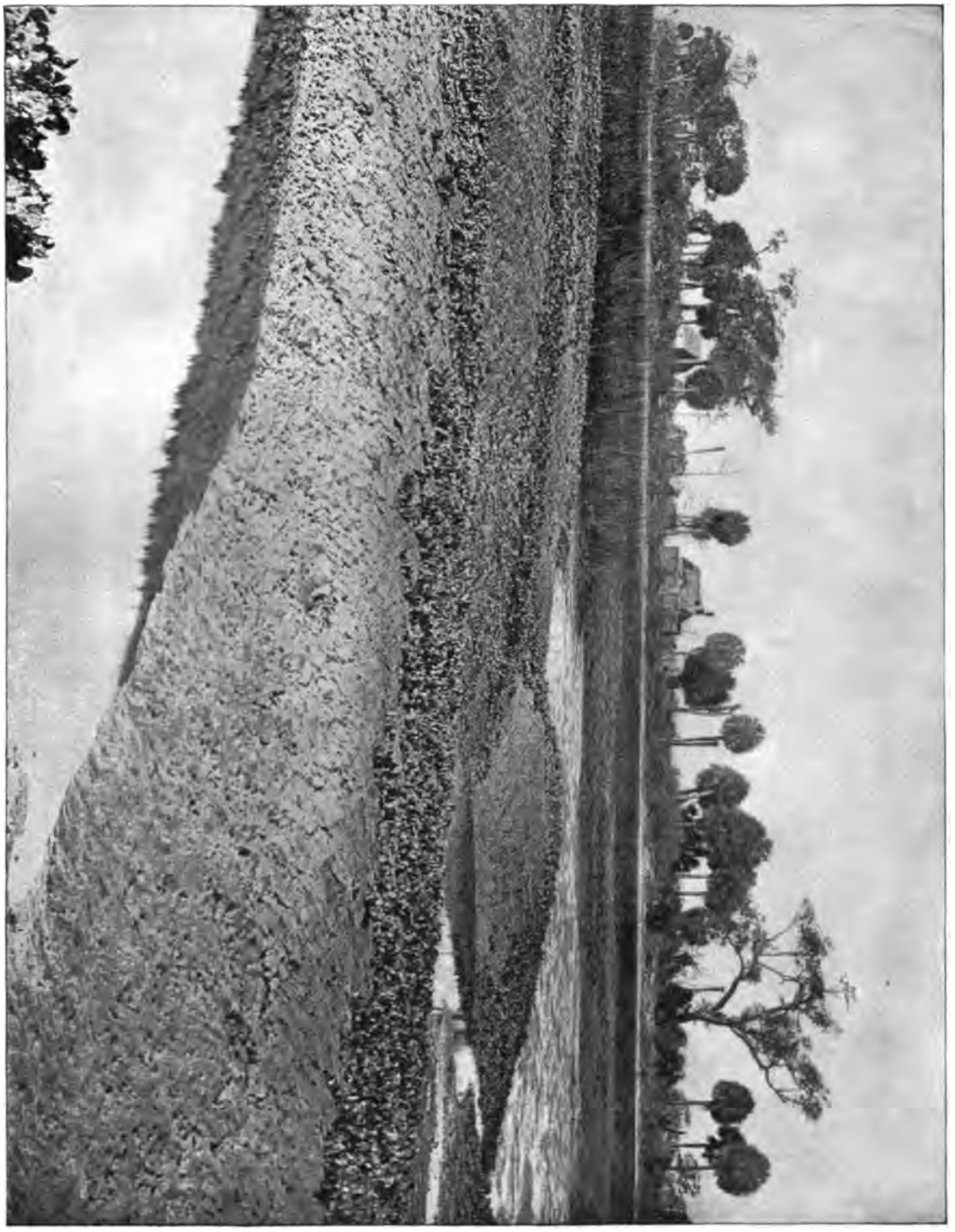
Table of analyses of South Carolina oyster-bed waters—Continued.

No.	Date.	Locality.	Weather.	Temperature of water.	Tide.	Depth (feet).	Specific gravity (corrected).	Chlorides (salt) (grains per gallon).	Total solids (grains per gallon).	Carbonates (grains per gallon).	Ammonia, parts per million.		Remarks.
											Free.	Albuminoid.	
	1891.												
144	Mar. 9	Ashley River, stream section at Charleston bridge.	Clear ...	59	H	Mid.	1.0227	2,397	2,601	7.55	.0033	.115	E. bank upon sediment.
145	9	.....do.....	...do	59	H	Bot. 8	1.0227	2,380	.....	7.6	.0026	.165	Do.
146	9	.....do.....	...do	58	H	.5	1.0227	2,380	.....	7.15	.0006	.102	Midstream, at drawbridge.
147	9	.....do.....	...do	57.5	H	Mid.	1.0223	2,402	2,687	7.25	.0019	.125	Do.
148	9	.....do.....	...do	57.5	H	Bot. 38	1.0225	2,419	.....	7.55	.0006	.0985	Do.
149	9	.....do.....	...do	58.5	H	.5	1.0225	2,368	.....	7.45	.0006	.135	West bank, 50 yards off.
150	9	.....do.....	...do	58	H	Mid.	1.0225	2,391	2,650	7.3	.0006	.130	Do.
151	9	.....do.....	...do	57.5	H	Bot. 4	1.0225	2,374	.....	7.6	.0006	.115	Do.
152	9	.....do.....	...do	58	L	1	1.0210	2,195	2,434	7.6	.0466	.095	E. bank.
153	9	.....do.....	...do	58	L	.3	1.0208	2,230	2,412	7.7	.0199	.145	Midstream at draw.
154	9	.....do.....	...do	57.5	L	Mid.	1.0201	2,288	2,500	7.7	.0066	.154	Do.
155	9	.....do.....	...do	57	L	Bot. 30	1.0201	2,244	2,581	7.75	.0099	.122	Do.
156	9	.....do.....	...do	57.5	L	.5	1.0207	2,234	.....	7.25	.0019	.16	W. bank, as before.
157	9	.....do.....	...do	57.5	L	Mid.	1.0205	2,234	2,609	7.25	.0013	.165	Do.
158	9	.....do.....	...do	57.5	L	Bot. 8	1.0211	2,234	.....	7.75	.0006	.180	Do.
159	11	.....do.....	...do	57	E	.5	1.0220	2,329	.....	7.8	.0166	.105	E. bank, as before.
160	11	.....do.....	...do	57	E	Mid.	1.0222	2,334	2,689	7.6	.0099	.11	Do.
161	11	.....do.....	...do	57	E	Bot. 7	1.0222	2,340	.....	7.5	.0099	.145	Do.
162	11	.....do.....	...do	57	E	.5	1.0220	2,352	.....	7.6	.0013	.066	Midstream, as before.
163	11	.....do.....	...do	57	E	Mid.	1.0222	2,368	2,709	7.6	.0166	.065	Do.
164	11	.....do.....	...do	56.5	E	Bot. 31	1.0222	2,374	.....	7.55	.0332	.0825	Do.
165	11	.....do.....	...do	57	E	.5	1.0218	2,352	.....	7.2	.0013	.106	W. bank, as before.
166	11	.....do.....	...do	57	E	Mid.	1.0218	2,352	2,703	7.35	.....	.106	Do.
167	11	.....do.....	...do	57	E	Bot. 8	1.0218	2,340	.....	7.2	.0006	.070	Do.
168	12	.....do.....	Rainy ..	62	F	.5	1.0198	2,201	.....	7.4	.046	.210	E. shore, as before.
169	12	.....do.....	...do	62	F	Mid.	1.0198	2,201	.....	7.5	.....	.....	Do.
170	12	.....do.....	...do	62	F	Bot. 8	1.0198	2,201	.....	7.5	.....	.....	Do.
171	12	.....do.....	...do	59.5	F	.5	1.0205	2,299	.....	7.5	.0066	.145	Midstream, as before.
172	12	.....do.....	...do	59	F	Mid.	1.0208	2,324	2,699	7.6	.0199	.1075	Do.
173	12	.....do.....	...do	59	F	Bot. 30	1.0208	2,324	.....	7.6	.0099	.1250	Do.
174	12	.....do.....	...do	59.5	F	.5	1.0203	2,267	.....	7.5	.0266	.160	W. shore, as before.
175	12	.....do.....	...do	59.5	F	Mid.	1.0207	2,286	2,680	7.6	.0332	.150	Do.
176	12	.....do.....	...do	59	F	Bot. 24	1.0206	2,299	.....	7.6	.0266	.135	Do.

FRINGING OYSTER LEDGE SHOWING LIVING RACCOON OYSTERS, AND THE METHOD OF FORMATION OF SHELL BANKS. STONO RIVER, EAST SHORE, 3 MILES FROM MOUTH, MARCH 6, 1891.



OYSTER FLAT, SHOWING MUD BANKS AND NATURAL DRAINING TRENCHES. SKULL CREEK, IN WEST MOUTH, JANUARY 13, 1891.



OYSTER FLAT, SHOWING MUD BANKS AND NATURAL DRAINING TRENCHES. SKULL CREEK, IN WEST MOUTH, JANUARY 13, 1891.

OYSTER ISLAND. A DENSE COMMUNITY OF RACCOON OYSTERS OCCURRING IN MUDDY, MARSH-DRAINING STREAMS. IN SMALL CREEK FLOWING INTO MAY RIVER, 1 MILE FROM MOUTH OF SKULL CREEK, JANUARY, 1891.

TIDAL ZONE OF OYSTER DISTRIBUTION IN SOUTH CAROLINA, INDICATED UPON PILING OF WHARF, SULLIVAN ISLAND, MARCH 12, 1891.

...MICHIGAN...

AN OYSTER FLAT, SHOWING FAR AND WIDE THE EXTENT OF RACCOON AREAS.

The plate presents more clearly the general character of an extended raccoon region, of which Plate LXIII illustrates but a small proportion. The locality, as in Plate LXIII, is in Skull Creek, near its west mouth, January 13, 1891.

MICHIGAN

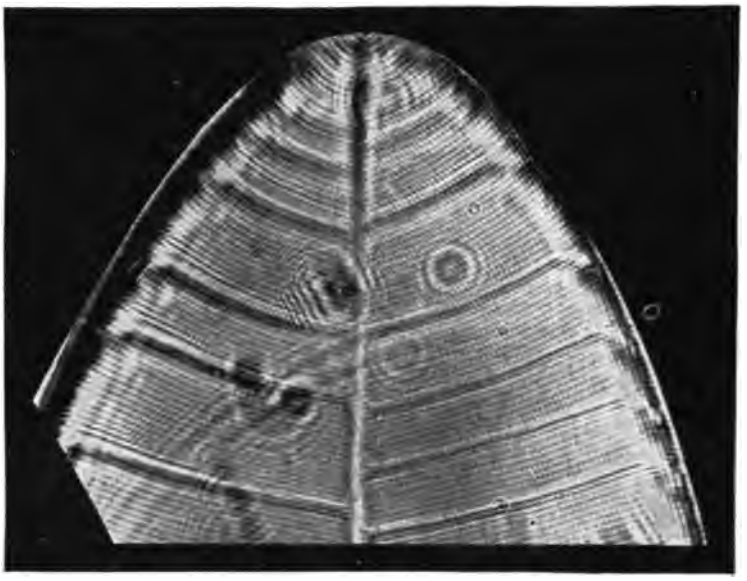


FIG. 1. A PHOTO-MICROGRAPH OF THE DIATOM, SURIRELLA GEMMA, ENLARGED ABOUT 1,600 DIAMETERS.

The tip of the frustule is alone given, to indicate the character and texture of the glassy surface. The photograph was taken with a one-fourth inch objective of Powell and Leland, by Prof. Wm. Stafford, of the College of the City of New York.

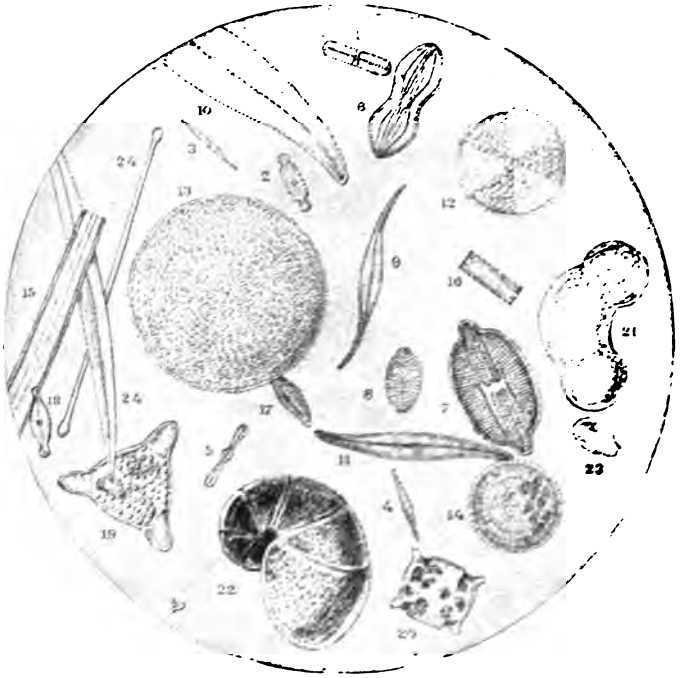
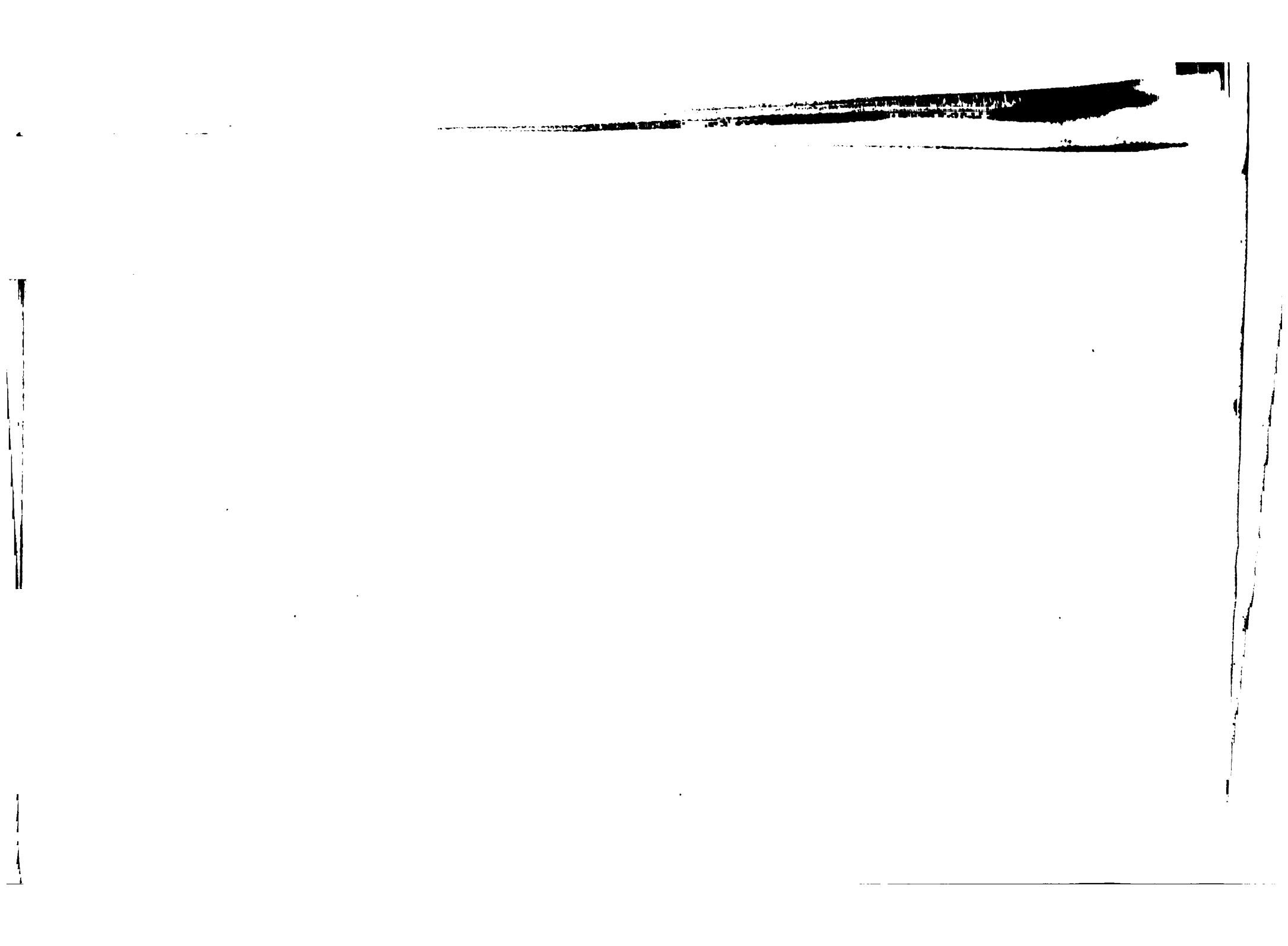


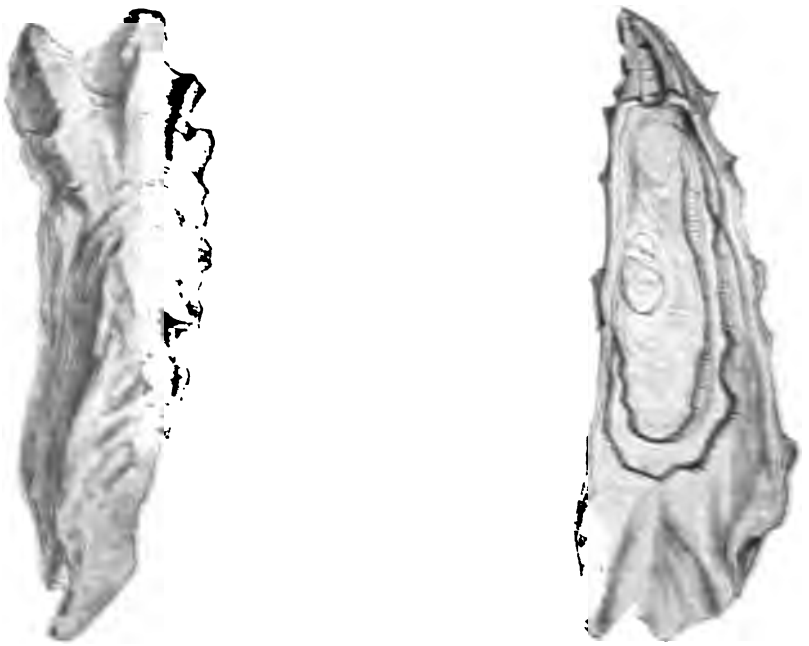
FIG. 2. FOOD OF SOUTH CAROLINA OYSTER. A FEW OF THE TYPICAL ORGANISMS (× 225).

Numbers 1 to 20 are diatoms.

1-5. Navicula (Bory).
6. N. didyma (K.).
7. Pinnularia radiosa (?) (K. S.).
8. Amphora sp. (K.).
9. Pleurosigma fasciola (E. S.).
10. P. littorale (S.).
11. P. strigosum (S.).
12. Actinocyclus undulatus (K.).
13. Coscinodiscus radiatus (E.).
14. Cyclotella rotula (E.).
15. Synedra sp. (E.).
16. Diatoma sp. (De C.).
17. Cymbella sp. (Ag.).
18. Mastogloia smithii (Thw.).
19. Triceratium alternans (Br. Bal.).
20. Biddulphia sp. (Gr.).
21. Grain of pine pollen (Pinus rigida).
22. Foraminifera (Rotalia).
23. Zoöspore (Ulva ?).
24. Spicules.



FIGS. 1, 2. FLAT OYSTER, OSTREA EDULIS. SPECIMEN FROM BELON, TWO AND A HALF YEARS OLD. Natural size.
Limit of size of *edulis* is about 4" × 4". These individuals were formerly regarded as a distinct species *pied de cheval*, *O. hippopus*.



FIGS. 3, 4. PORTUGUESE OYSTER, OSTREA ANGULATA. SPECIMEN FROM THE TAGUS. (p. Page 365.

(Figures from drawings by the author.)

...Y OF MICHIGAN

14.—THE PRESENT METHODS OF OYSTER-CULTURE IN FRANCE.

BY BASHFORD DEAN.

I.—INTRODUCTION.

The studies upon which the present report are based were conducted by the writer during the summer and autumn of 1891, under instructions from the United States Commissioner of Fish and Fisheries. The discussion of the results of his observations has been made as pertinent as possible to the conditions of the American waters.

When one has carefully examined oyster-culture in France, it appears more than ever manifest why the industry at home has been a profitable one. It has certainly required the exercise of but little labor, and all costly methods of cultivation could have proven of little practical value. So great has been our natural supply of oysters that we have always thought far distant the need of replenishment.

If, however, the present condition of our industry must be improved, there are fortunately but few natural obstacles to overcome, and we may well be hopeful. Our oysters are of a hardy and prolific species, our coast is a natural collecting place for seed, and the conditions of our oyster-bearing grounds are practically as good as ever. We have in no degree the adverse conditions that the French have so successfully encountered. Their coast regions, in the first place, favorable to a natural growth of oysters, are both few and small. Their waters, even in some of the best-known localities, are often turbid, accumulate sediment, and give rise to shiftings of muddy bottoms. Culture has had to bring into use the softest flats and mud banks, crusting them over with gravel and sand; it has had to devise every possible way of protecting its oysters from sediment, mud burial, and enemies. Finally, there are but two points along their entire coast where seed oysters occur in any natural abundance. Skill in culture, however, has enabled Arcachon and Auray to supply readily the great home demand for seed, and even to furnish in large part the parks of the Low Countries and England, a success the more remarkable when we consider how recently was the French coast so depleted that for the first experiments in cultivation the oysters were actually purchased from other countries.

Natural difficulties have caused the French to study division of labor in the industry; to make, for example, one locality furnish the seed, another to raise the oyster to maturity, a third to flavor or color it, and sometimes even a fourth to prepare it for transport.

Under these conditions the growth of the industry has been especially and almost entirely dependent upon the wise action of the Government. The reservation of the

natural grounds as state property and the forbidding of general public dredging is generally regarded as the keystone of French oyster-culture. These grounds, once exhausted, now flourishing, are regarded as the permanent capital of surrcunding areas, whose profits in the form of seed oysters are shared by all alike.

The state exercises the additional right of surveillance in the interest of culturists through the local commissaires of marine, and of regulating and changing the terms of state rentals.

The industry is a profitable one to the culturist. To the state it returns in rentals a greater revenue yearly than the total sum expended in the failures of Coste. Competition, moreover, on the side of the culturists is operating more and more favorably for the people, insuring a product for general consumption.

Throughout my visits of inquiry every courtesy was extended to me by oyster-culturists. The inspector-general of fisheries, M. Bouchon-Brandely, gave me most important aid and counsel, while the minister of marine, M. Barbey, instructed the commissioners of marine at the different oyster stations to facilitate my observations in every way possible. The following localities were visited, designated mainly by M. Bouchon-Brandely as typifying the branches of the oyster industry: Cancale, Roscoff, Belon, L'Orient, Auray, Breneguy and Trehennarvour, Trinité, Vannes, Sables d'Olonne, Marennes, La Tremblade, Rocher de Der, Arcachon, La Teste, and Ossegor.

Oyster-culture in France is decidedly of recent origin. It is but little over a half century ago that the natural oyster banks of the coast were, like those of the Chesapeake, deemed inexhaustible, and were still allowed to be dredged even by foreign vessels. The French government at length realized how necessary was state intervention to save the entire industry, and laws were passed regulating stringently how and when the few remaining oysters might be dredged. More important still, the agitation of these measures led to the question of replenishment as the important problem. In 1853, M. de Bon, commissaire of marine at St. Servan, made his historic experiments upon the fixation of young oysters upon bits of wood and stone, and found that by suitable arrangement the oyster growth might be rendered far more rapid. The importance of practical use of "collectors," as the sticks and stones were termed, was at once taken up most enthusiastically by M: Coste, professor of embryology in the College of France. For additional light upon the subject, Coste made his visit to Italy, searching the processes there retained of the famous Roman oyster-culture. His report, supported by a successful experiment, made what was virtually a proposition to replenish the banks of the entire coast. Though the proposition was looked upon at the time as at the best impracticable, it was too tempting a one to be put aside. Napoleon III. became discreetly interested, and secured an appropriation for the carrying on of extensive experiments. Coste firmly believed that his work was to be of the greatest importance to his country, and that his success was to be immediate. He entered ardently into his rôle of oyster-culturist. Unfortunately he was ill advised in his choice of experimental stations, seasons were unfavorable, and he failed in his entire undertaking. His failure he recognized more keenly than did his enemies. "He died, blind, in disgrace, looked upon as almost a charlatan." What Coste did for the cultural industry is now well recognized. He certainly centered upon it public attention and pointed out clearly what should be done. It was he who furnished the ideas for others to profit by.

Since the time of Coste numberless improvements, great and small, have been added and have made the industry practicable and profitable.

II.—THE OYSTER IN FRANCE.

ITS SPECIES AND CHARACTERISTICS.

In the French markets oysters are first distinguished as either "flat" or "Portuguese" (Plate LXVIII). The former is the oyster of Northern Europe, *Ostrea edulis*, esteemed for its flavor and commanding a higher price; it is the species that is especially cultivated. The latter, *O. angulata*, is a modern importation, lacking in flavor, introduced as a substitute for the more delicate *edulis*.

The *flat oyster*, as the name implies, is readily recognized by the shape of the shell. This is round in outline, flattened, large in proportion to the size of the animal. The shells are often quite smooth outwardly; the lower valve, spoon-like in our American species, is scarcely as concave as a shallow saucer.

The Portuguese oyster is typically long and irregular. One valve is deeply trench-like and contains the entire animal. The opposing valve is smaller, thinner, and recurved. The shell is heavy, rough and angular without, and coarse of texture within. When the shell is opened, the oyster appears slaty or bluish in color, outlined with the broad, jet-black margin of its mantle. Its taste is salty, bland, peculiar to itself, and somewhat sweetish. The flat oyster shrinks vastly on its opened shell, is faint in color, with a brown or pinkish margin. It possesses that piquant taste, perhaps slightly metallic or "coppery," so highly prized by the connoisseur. The contrast between the species in point of taste is considered more striking than the outward differences in shell.

As regards natural conditions of living, the flat oyster occurs rarely in clusters and is found in deeper and salter water (sp. gr. about 1.026*). It may, moreover, slightly change its position and thus tend to keep itself above the mud. The Portuguese oyster occurs naturally along shore and in clusters, in water of a less density (about 1.023) and of a somewhat higher normal temperature.

It may be of interest to continue the question of differences in order to understand more clearly the position occupied by our American oyster.

The long-discussed bisexuality of the flat oyster is in Europe generally conceded; the American and Portuguese species are regarded as monosexual. If the flat oyster possesses this anomalous sex character, its genealogical relationship to other species will be difficult indeed to determine. The Portuguese oyster, still looked upon popularly as a *Gryphæa*, must take precedence from geological antiquity. It certainly is the least prone to form varieties. The American oyster appears to be intermediate. The flat oyster is in many ways most specialized, and presents over thirty recognized varieties, several of which were formerly regarded as distinct species.

* The extreme saltness of the waters of the French grounds shows quite clearly why the introduction of the American oyster has always been unsuccessful. Our oyster is comparatively a brackish-water form, occurring naturally in river mouths and sounds liberally supplied with fresh water (sp. gr. 1.017). At Arcachon, where the density of the water is low (1.022 to 1.024), American oysters have been known to live for years, but without reproducing.

Continuing the contrast between flat and Portuguese oysters the following differences are noteworthy:

FLAT OYSTER.

Shell grows laterally at the expense of thickness; is usually light, friable, very large in comparison to size of animal; its margin is undulated by a dozen or more flattened projecting ridges. The lateral method of growth is marked by a circling fringe of straw-colored cuticle, *dentelle*. The saucer-like valve is the more robust at the free margin and indicates outwardly, by slight asperities, the concentric rings of growth. These are sometimes outlined by a slight violet tint. The upper valve is usually quite flat, showing from within a broad band of translucent cuticle often an inch in width. Outwardly this valve is shingled with irregular overlapping bands of horn-colored cuticle. The nacre is frequently pearly, of a pinkish cast. The hinge is slight, allowing the oyster to be opened hingewise. The breadth of ligament is suggestive of *Pecten*, a likeness often made still more striking by the flat, angular processes thrown out by the shell on either side of the hinge. The shell moreover is circular and ridged, like *Pecten;* its muscular impression, too, is central and usually colorless. A degree of movement might therefore be suspected, though the adductor muscle does not appear relatively large.

The mantle is delicate and broad-margined, contracts vastly, forming irregular plaits; its sensory margin is wide, generally pale pinkish or brownish in color; papillæ abundant, small, and needle-like; posterior flaps of mantle wide and prominent. The transparency of the mantle permits the viscera, liver, intestine, and rectum to be generally outlined. The crystalline style is dense and prominent.

In habits, the *edulis*, as before noted, gradually separates from the object to which it had attached. In muddy localities it is enabled to survive by opening and shutting its flattened scallop-like valves, to retain a horizontal position. When out of water the quick snapping of valves and forcible ejection of water are noteworthy. With gradual shifting of bottom the oysters are enabled to alter their position considerably, tending, it is said, to congregate in banks. In all of the oyster ponds examined during the summer the density of the water was found to be extreme, practically that of the sea, of a mean sp. gr. of about 1.026, and in range from 1.020 to 1.028. In relation to the question of spawning it is remarkable that at the two centers of seed production, Auray and Arcachon, the water densities have been found lower (1.022 to 1.024) than at other localities examined. It would naturally appear therefore that, aside from the question of silt deposit, probability for spat-catching seems to decrease as the water increases in saltness.

PORTUGUESE OYSTER.

Shell shaped roughly like a human foot, but distinctly pointed at the heel. The external ridges become at the margin deeply accented, forming notches grotesquely toe-like. The valves thicken rapidly, their plane of growth becomes tilted and undulate, and their limy growth extends to the free margin of the shells, with cuticle lacking. The deep valve is trench-like, with usually a recess under the hinge, and with free edges appearing to arch over. Its depth measured externally is often five times that of the opposing valve. Its outward asperities are prominent and irregular. The upper or right valve is depressed, but resembles outwardly the lower one. The nacre is limy and irregular, often greenish in color, and often darkened in patches where invading mud masses have been cemented in. Hinge ends of shell heavy and pointed, that of lower valve produced backward, spur-like. Hinge ligament, located in deep notch, is stout and defends the oyster from being opened hingewise. The muscular impression, usually purple, is small, oblong antero-posteriorly, its muscle attaching the shell near the median of the posterior margin. The oyster is therefore opened by a knife thrust at the side.

The oyster is sunken in its deep shell. Its mantle is narrow and opaque, outlined with a broad, jet-black, sensory band. The sense papillæ are finger-like in shape, large and long. Posterior flaps of mantle not marked.

The Portuguese oyster is naturally a clustered form, occurring in shallow water of a mean normal temperature of 65 to 70° F. The weight of its cluster keeps it firmly rooted in its native muddy sand. All of its conditions of living appear to be those of the *O. virginiana* in South Carolina (*vide* U. S. F. C. Bull., 1890, p. 336). The clusters are often of great size, composed of a hundred or more individuals. The oyster separated from its cluster and grown on a sandy bottom improves materially in flesh and shell. It is a littoral form, though not occurring in waters notably freshened, the densities over the oyster beds at the mouth of the Tagus (middle of September) ranging from 1.023 to 1.0255.

NATURAL OYSTER BANKS AND DREDGING.

On the French side of the British Channel the natural oyster beds, or "banks," as they have been termed from their original mound-like form, have been struggling to regain their prosperity, aided by the stringent regulations governing the dredging. At favorable points, as at Granville, Cancale, and St. Malo, they have again become valuable. As supplying the general market, however, their importance is little to be compared with that of artificial culture. Where the natural banks become of the utmost importance is in the regions of productive oysters, as giving the seed oysters for surrounding areas. Here their reservation is made most absolute, their limits are determined and guarded, and their condition from time to time examined by careful dredging. In general, government assumes the management of the natural beds, prescribes how, when, and by whom dredging may be carried on, and enforces the law that oysters under the standard size shall be sorted out from the dredge and be at once returned to the water.

As to the banks and the dredging, the natural banks have originally clustered around a series of half-buried rocks and have spread out by the acre as the oysters have become detached. The bank depends naturally for its shape upon the character of the bottom and upon currents; in general, however, it lengthens out irregularly coastwise. Some of the most important banks exist far out from shore, located upon reefs or flats in water of 20 or 30 feet, or even deeper. Others exist in clusters but a few rods from shore and are uncovered at low tide.

Dredging within prescribed limits is, as at Cancale, granted so seldom that such occasions have become like holidays.* The *chaloupes* (3 to 10 tons) are drawn up ready for work and the beach is filled with spectators. At a cannon shot the little vessels start as in a regatta (see Plate LXIX, Fig. 1), each striving to be first on the ground. The dredges, four or five to a boat, are operated by half a dozen fishers. A cannon shot closes the dredging and the little fleet returns shoreward, usually well laden. The vessels are now beached, and the cargo is thrown out upon the sand as the tide descends. The mass of oysters is at once attacked by women and children, who sort the oysters out in regard to size and place them in oblong wicker baskets (Plate LXIX, Fig. 2). The oysters may now be sold for *élevage* in the slightly freshened waters of the neighboring parks.

Here, as elsewhere, the dredged oyster must be fattened to gain for it a favorable market price, since it is poor in flesh, dark in color, and as yet little able to bear the fatigues of transport.

The operation of dredging would be regarded by our Connecticut culturists as of a most primitive character. Hand labor is economical and prevails, and the entire dredge net is often of hempen cord. The dredge iron is curiously light in construction, braced all about with soft iron rods; the mouth is nearly 6 feet in width; its broad lower brim is bent abruptly downward to scrape the bottom at an angle of 45°.

*The time allowed for the dredging of the natural banks during the past year has, I have been told, averaged between two and three hours.

III.—OYSTER-CULTURE AND ITS BRANCHES.

French oyster-culturists are engaged either in collecting the young oysters (*production*) or in raising the seed for market (*élevage*). The *éleveur* buys his seed directly from the producer and is little interested in the question of dredged oysters. In our discussion, therefore, it will be most convenient to take up the processes in their regular order. We shall thus see, for example, how the swimming fry of the oyster becomes attached to the cement-coated collector, and how afterward, when the size of a finger-nail, the young oysters are separated and sold. Here begin the duties of the *éleveur*. He arranges the seed in wire-gauze growing cases till they are large enough to be little injured by enemies. He may then economize case room and transfer the oysters to inclosures fed daily by tidal water (parks). Or still further, the oysters may be specially fattened or given a desirable color by a sojourn in a shallow, long-stagnant pond (*claire*). These may finally secure a higher market price by processes of cleansing or of education for transport.

PRODUCTION, OR THE RAISING OF SEED OYSTERS, AND KINDS OF COLLECTORS.

Now that the supply of seed oysters along the Atlantic coast is becoming depleted by the increasing demand, the question of how the French have developed their industry practically without seed beds is of serious importance. If we have now to undertake artificial production on a large scale, we have evidently no need of repeating experiments already found fruitless.

In France, ever since the time that de Bon showed how swimming oyster fry might be collected upon sticks and stones, every trial has been made of ways and means to produce the greatest number of seed oysters at the least expense. As collectors they have anchored bundles of brush, built platforms of wood, suspended strings of shells. The serious difficulty was always that the collectors would become speedily coated with slime or sediment, which would either stifle the young oyster or, at the best, prevent it from attaching. For this reason our method of simply scattering broadcast over oyster-grounds shells or pebbles as collectors would in French localities prove of little value. It became evident, therefore, that a collector must be of a shape to render it least liable to become coated with sediment. This requisite was found in the roofing tile.

A tile may be to us somewhat of a curiosity. One must imagine a shingle of brick so arched as to appear like the side of a tall flower pot, hollowed, therefore, on its under side. Its length is about 14 inches, its width 6 inches at one end and 5 at the other. Its arch is a slight one; the curve of one-fifth of a circle is found best adapted for purposes of collecting. It is this slight curve, however, that gives the tile its principal value in oyster-culture. Its under or hollow side becomes a recess almost free from sediment and may be crusted with spat, while the upper side is slime-coated and unproductive.

Experiments as to the best way in which the tiles should be arranged showed, first, that tiles should be banked up in tiers, rather than spread out horizontally, in order to place the collectors above the reach of the bottom sediment. A second deduction was that the collectors should be placed along beach strips near the line of low water, thus to evade sediment, because of surface waters, yet at the same time to allow the collectors to be rarely exposed.

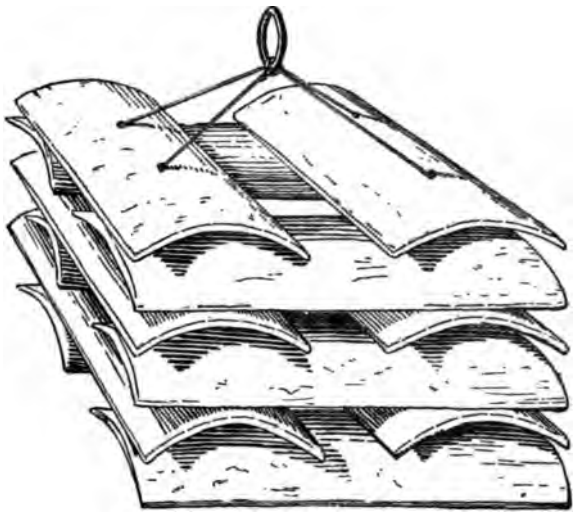
Formerly, when the young oysters had become about an inch in diameter, the tiles were skillfully broken or cut by means of heavy pincers, so that each oyster should have attached to it a fragment of tile; this was regarded as of great value, protecting the delicate mollusk against its enemies. This method of separating the oyster is, however, now obsolete, except under a modified form in several establishments along the Trinité River. It became too expensive a matter to destroy the tiles—the oysters must be separated and the tiles saved for the coming season. At length a thin coating of lime cement was found to answer the purpose, proving even better than the tile itself for "set," while allowing the young oyster to be flaked off even by a push of the finger-nail.

This innovation brought the tile more and more into general favor. Their use was now found economical; costing at the outset but $5 or $6 per thousand, they became fairly permanent, for even the percentage annually broken in handling (about 5 per cent) could be made of use in special forms of collectors. Moreover, besides giving the greatest surface for attachment of spat, they might by their arrangement in tiers economize available space; they might readily be handled and stored, yet be sufficiently heavy to withstand the wear and tear of the water. It is stated that at Arcachon and in the regions of Auray the yearly average of each tile is at least 200 seed oysters.

With this brief introduction we may examine the three typical forms of spat-collectors in present use and their method of employment. Varieties in tile collectors are naturally dependent upon the place to which they are destined, upon the softness of bottom, upon tides, and sweep of currents.

(1) Where the bottom is suitably firm, with but little water at low tide, the *gabarét* (*ruche*) is perhaps the most popular collector (Pl. LXXI, Fig. 2). It may be described as a crate of tiles. The accompanying figure represents the form used by M. Dasté, of Arcachon, undoubtedly the most convenient of those I have examined. The crate is made of strips of wood, 2¼ by 1¼ inches, with the ends pivoted, so as to allow the frame to be folded for transport and storage. The wood is tarred once a year by immersing the entire frame in a tar vat. The measurements permit ten tiers of tiles and allow nine tiles to a tier. For solidity the tiles in the different tiers alternate lengthwise and crosswise, their wedge-like shape dovetailing the mass firmly together, the lighter upright strips preventing their displacement. In actual use the uppermost tiles are usually roofed over with seaweed, as a protection against the heat of the sun, should the collector be exposed. The collector described is arranged for the largest size of tiles, preferred by M. Dasté as more economical in handling. *Gabaréts* are often employed holding a greater number of smaller tiles, 120 to 200, gaining thereby a greater exposed surface for fry attachment. A modified *gabarét* arranges the outer tiles and fills in the central portion with the tile fragments broken in *détroquage*.

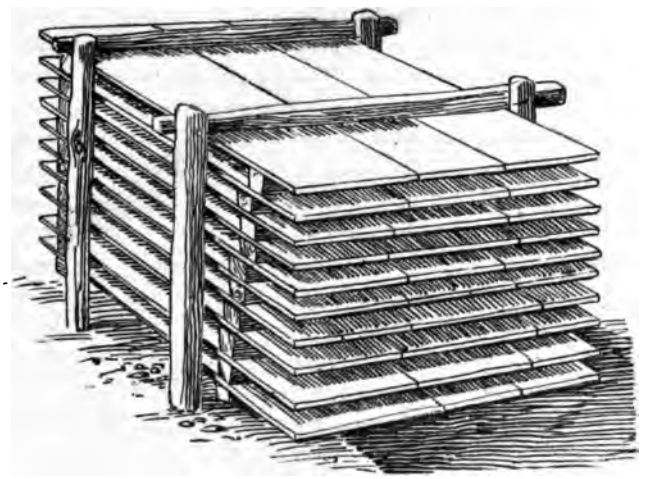
(2) Another type of collector is the *bouquet*,* employed when the bottom is suitably firm, but where from depth of water the *gabarét* is inconvenient. This collector is simply a bunch of a dozen tiles strung together in different ways by galvanized wire. Its wire loop is readily seized by a boat hook, and its compactness makes it convenient in handling.



The *mushroom* is the form almost exclusively used where the banks are soft, or in deeper water where there is a heavy bottom sediment to be avoided. Without this collector many localities would be rendered absolutely worthless. It is simply a *bouquet* raised a foot or two above the bottom, hung by its wire ring to the top of a firmly driven stake. All the attendant care is readily given from flat-bottomed skiffs as the tide is falling.

Another modification of the *bouquet* is the *camion* (Plate LXX, Fig. 2), a collector used in place of the *gabarét* in localities where the current is not too strong. It is a *gabarét* lacking the wooden frame, formed by banking together *bouquets*, one above the other. It is therefore readily taken apart and handled. To aid its stability it is sometimes weighted by stones.

(3) In place of the *gabarét*, equally exposed by the receding tide, there is often employed a *planche collecteur*, or a bank of a dozen horizontal wooden trays (Plate LXXI, Fig. 1). This collector is kept in position by rough uprights driven into the ground, which serve from year to year. The wooden trays are easily removed and transported for *détroquage* or reliming.



We must now examine (1) the way in which the tiles are coated with cement, (2) how the collectors are put in place, and (3) how the young oysters are afterward separated.

* The *bouquet* is shown in the upper figure; the second figure represents the *planche collecteur*.

COATING WITH CEMENT (CHAULAGE).

Early in the spring each proprietor causes his collectors to be thoroughly sun-dried. The cement vat is then prepared with a mixture of lime and sea water, often with a proportion of sand or mud stirred to the consistency of thick cream. The collectors are rapidly dipped in this limy fluid, allowed to drain off, arranged on rough trays, and set aside for several days to thoroughly dry. The cement crust should then be about a millimeter in thickness, somewhat brittle, separating from the tile in flakes. The dipping of the tiles in cement is sometimes performed by hand, sometimes by means of a well-sweep. The operation is a rapid one, the attendant women on one side of the vat passing up the tiles separate or in bunches, as in *bouquets*, for immersion; another detachment promptly removes the moist collectors and spreads them to dry. A new tile is first saturated with a watery mixture of quicklime and water, to fill the pores in its spongy substance. It is then dried and subjected to the regular process.

Of the properties and ingredients for *chaulage* each proprietor has his own recipe. At Arcachon the formula is in general that of M. Dasté: one part quicklime, three parts fine sand, with coloring matter sometimes added. In the region of Auray, M. Martin gives his tiles a double liming, first with a light coating of quicklime, and second, after the tiles have dried, with one of hydraulic cement. In the Trinité River region, M. Leroux prepares a mixture of one part quicklime and one part of fine gray mud, as best suited to his locality.

PLACING AND MANAGEMENT OF COLLECTORS.

In localities where spat collection is naturally favorable, as at Arcachon and in the region of Auray, the tide limits along the beaches will be seen covered with collectors (Plate LXX, Fig. 1). These are most numerous near the low-water mark, usually arranged in close regular order, but with alleyways between leading shoreward, wide enough for the passage of a cart or boat. In placing collectors it is usually arranged so as to allow the current to run counter to the length of the tile, in order thereby to gain nodes of still water under each tile as places of refuge for the young oysters. It is claimed, however, that this precaution is a needless one. The matter of the greatest importance, universally conceded, is *when* the collectors should be put in place. Experiments have shown that in localities of French production the placement should be arranged during the low tides of the last week in June and of the first fortnight in July, and that the bulk of the collectors should be in position by the commencement of July. The question of time is carefully studied by the culturist. He examines the oysters from time to time, looking for the *gray* spawn, the nurslings which the oyster is about to eject. As long as the spawn is white or creamy in color the culturist defers the placing of collectors. As the collectors so speedily become slime-covered, the question of a few days is regarded as of the greatest importance for the success of the set, since the major portion of spawning is found to take place quite suddenly. The anxiety of the culturist in regard to exactness of time seems one that should be carefully considered at home, for the habits of the fry appear to be very similar to those of our own, especially as it is now conceded that the swimming stage of the European species lasts for several days, or even a week.

The set once obtained, there is nothing to do but wait till growth has rendered the young large enough to be safely separated from the tile. They have attained by

October at least the size of a finger nail, and *détroquage* commences, this operation being often finished before the coldest weather. Some proprietors allow the oysters to remain unseparated until spring—Trinité River, for example—but in shallow waters there is danger of losing the entire set from freezing.

DÉTROQUAGE AND TRANSPORTATION.

Détroquage begins with the carrying of all the collectors to the neighboring shops (Plate LXXII, Fig. 1). Everything is made ready; the *camions* and *gabaréts* are carefully taken apart and the tiles placed on lighters; as the tide rises these are gradually floated ashore and promptly unloaded. Each cargo is precious to the proprietor, for he can at once sell the tiles for immediate transport at an average price of $10 per 100. The tiles are arranged in small heaps, and the operation of separating the seed oysters commences. The plaster coating of the tile, softened by water, is readily flaked off with the oysters adherent, by short pushes of a chisel-like knife. The women who perform the task become extremely skillful, each separating perhaps 20,000 seed during the day. The loss is but trifling, estimated in general from 2 to 5 per cent.

The young oysters are at once placed in baskets to be transferred to neighboring growing ponds, or are packed directly for transport. Their price is a variable one, dependent upon size, locality, and scarcity, but usually ranges from 50 cents to $2.50 per 1,000.* Each proprietor has his *clientèle* of *éleveurs* and finds but little difficulty in disposing of his product. Curiously enough, transportation at this stage does not appear to be dangerous. The proportion of seed lost during a journey of three or four days is but trifling. I am told that even after a stormy transport from Auray to the Irish coast, taking in all nine days, more than two-thirds of the cargo was found in good condition.

Before concluding the discussion of seed oysters, a few words must be said (*a*) in regard to production in closed ponds, and (*b*) of the importance of the reservation by Government of oyster-bearing tracts.

Production in closed ponds.—All production thus far considered has been that of open bays or rivers. Here, however, everything is at the mercy of season and weather, and profits every culturist alike. The French, however, recognize that the ideal production can only be carried on in closed ponds provided with spawning oysters, where by favorable conditions a great percentage of the myriads of young might be successfully collected. During the present season a most remarkable success in this production has been made by Mme. Veuve de Saint-Sauveur, in her lake at Breneguy, adjacent to the mouth of the river Auray. Experiments in this line have usually failed the second year; but in this case the principles seem far more likely to promise continued success. They are at least worthy of discussion.

The lake is, in the first place, a large one, covering a rounded basin of about a hundred acres (Plate LXXVII, Fig. 1.) It had originally been a salt marsh, of a bottom naturally clayey. It was converted into a pond by constructing a high bank on the one side and finishing the inclosure by a massive sea-wall on the other. Here, as the tide is favorable, two great flood-gates prevent the escape of the water, allowing an average depth to be maintained of about 4 feet. The management of the lake has been an extremely rational one. During the past winter the pond had been well dried,

* A letter from Arcachon tells me that the set of the present year has been so great that the price has fallen to 10 cents.

allowing the basin to thoroughly purify, and during this time the muddy tracts had been roughly macadamized with clay and gravel. About the middle of April the water was gradually admitted. A week later oysters were introduced to furnish the spawn. These were scattered in the deeper parts of the lake at about forty to a square yard. The water was now daily changed at the flood-gates till the first appearance of spawn (May 15). This was the sign that the collectors should be put in place and that the flood-gates should be closed. Since that time, up to September 1, no water and consequently no oyster fry had been allowed to escape. Loss from evaporation was several times made good by allowing the entrance of tide water, a precaution hardly necessary because evaporation had in a measure been counterbalanced by several small springs occurring in the bottom of the lake. These, moreover, exercised a very salutary effect in keeping the gravity of the water slightly lower (1.021 to 1.023) than in the open harbor. The temperature of the confined water became gradually higher (5° to 8° F.) than that without, while the water volume was yet sufficient to guard against sudden changes of air or weather. Obviously, absence of strong currents tended to a minimum of sediment accumulation. It was soon evident that the success of the experiment was a pronounced one. A dense set was apparent throughout the entire bottom. The spat had even attached to the stouter sea-weeds. Owing to a minimum of sediment both sides of the tiles in the collectors were usually well covered, each tile showing on an average 400 spat. The set was sometimes as dense as 3,000 per tile.

The principles to which Mme. de Saint-Sauveur has attributed her success are as follows:

(1) The necessity of inclosing a large area in order to present a great water surface for the absorption of air.

(2) The necessity of thoroughly drying out the basin for at least two months, doing away entirely with animal and plant life and allowing the clayey bottom to become purified for the following season.

(3) In the management of the pond the necessity (1) of introducing a small but continued supply of fresh water to compensate for evaporation; (2) of a uniform and low density (1.022); (3) of a depth of water sufficient to guard against sudden changes in temperature or density.

The success in the management of this closed pond has been so remarkable that if continued during following seasons it will insure the establishment of permanent stations of this character. It is noteworthy that from the time that water was allowed to fill the dried basin a healthful condition prevailed and was apparent throughout. Sea-weeds became sufficiently abundant to aid materially in oxygenating the waters, and to provide the richest of feeding for the contai oysters. In former experiments the difficulty has been malaëration, causing the death of animal life and the subsequent empoisoning of the water. Breneguy has refuted most clearly the doctrine of Chaumel, Gressy, and de Wolbock, that "current is indispensable to the life and transport of oyster fry."* The question seems rather one of perfect aëration and of lack of sediment.

In relation to our present need of seed-culture the success at Breneguy should be seriously considered. The ease with which our species of oyster may be artificially fertilized would allow us to introduce in a pond of this kind myriads of active fry, could we be but sure that natural conditions would be favorable for their set. We

* *Vide* Hausser, ref. 47, 22.

might thus, it is evident, determine absolutely the time to place collectors and to close and open the tide gates. At home all experiments have failed owing to imperfect aëration. Efforts to renew the water by supply and drainage currents have led to the escape of the embryos; while, if the basin has been entirely closed, its smallness, together with accumulations of sediment, has usually resulted in leaving the collectors far less covered with spat than if they had been placed in the open water without. In Europe artificial fertilization of the flat oyster is impracticable, since the fry are retained and incubated by the maternal shell; hence, in pond culture, there will be necessary the troublesome task of introducing, examining, and guarding the spawning oysters.

Experiments by Bouchon-Brandely in 1881 with fertilized eggs of the Portuguese oyster are clearly set forth in his report.* The embryos were successfully reared in small ponds, but the success was not sufficient to warrant profitable culture.

Reservation by Government of oyster-bearing tracts.—To the Government as well as to the culturist the oyster industry is a profitable one. It is, therefore, state policy to foster its development. This it has done most judiciously in the regions of seed production. Oyster-bearing tracts centrally located have been staked out and rigorously guarded to furnish spat for the entire neighborhood. These tracts are intended to include all depths of water and all conditions suitable for production. The importance of these measures can not be overestimated. Without it seed production would become impracticable. Everybody's business would otherwise become nobody's business, for the culturists would have a jealous dread of retaining oysters to furnish fry for the entire neighborhood. The condition of these reserved grounds becomes a matter of great importance. A committee is appointed to represent the different estates and to control their management. This committee causes the grounds to be regularly examined, and experiments and reports upon questions relating to dredging, cleaning, or replenishing the banks.

ÉLEVAGE, OR THE GROWING OF OYSTERS FOR MARKET.

The question of obtaining seed oysters is regarded in France as a certain and not a costly affair. The time and expense devoted to the oyster are during its *élevage* or process of cultivation. The *éleveur* receives seed oysters which, perhaps, are but the size of a finger-nail. He must place them under their most favorable conditions for growth and fattening, must care for them, and must in the end send them to a critical market as cultivated oysters, perfect in shell, well-fattened, and delicate in flavor. He must, therefore, make a study of his locality, to find what conditions are most favorable for rapidity of growth or flavoring. His work begins when he receives the freight of millions of seed from Arcachon or Auray. These are unpacked, carried down to the low-water line, and arranged in the flat wire-gauze rearing cases (Plate LXXII, Fig. 2). These he regards as important to the industry as the tile itself, for in the first place the cage lifts from the bottom and prevents the young from being stifled by the shiftings of mud; it renders the growth regular and rapid, and above all it protects the oysters from their enemies—crabs, boring snails, and starfish. The mortality of oysters during the three years of their *élevage* may by case culture be reduced as low as 10 per cent.

* V. ref. 9, e.

The case is not a costly affair; it is merely a large flattened box, whose top and bottom are of stout wire gauze; it is about 6 inches in thickness, 6 feet long, and 4 feet wide. This shallow wire-gauze box or tray is held a few inches above the bottom by four corner posts; its lid when in use is held in place by four nails at the corners. Where rough usage is expected, as at Cancale (Plate LXXII, Fig. 2), the supporting stakes are increased in number, the wooden frames of the lid and bottom are made wider, rendering the gauze window-like, and the lid is hinged, held in place by weights or a lever. In the Trinité River, M. Benjamin Leroux outlines the gauze of the top and bottom with iron, instead of wood, thus allowing both to be readily lifted from the frame convenient for storage and tarring. This device, however, is generally regarded as a matter of needless expense. At Arcachon a modification occurs as adopted by M. Dasté. The tray, formerly single, is now formed of three smaller ones side by side. By this change the separated trays become convenient for partial transportation. A single lid, as before, covers this compound case. All cases are furnished with gauze of galvanized wire, with a mesh varying from one to three to the inch. If tarred regularly once a year the cases last from ten to twenty years.

The cases are arranged near the line of low water with a view of keeping them submerged as long as possible. They are placed side by side in lines, with alleyways between passing shoreward. The corner pickets may thus be made to serve on either side. This double service is most successfully attained by means of the cast-iron pickets of M. Martin. These are T-shaped, with ledges on either side at convenient heights to support the case frames; they are readily put in place and are obviously permanent. The first task of the *éleveur* consists, as we have noted, in placing the seed in the cases. These are strewn thickly, sometimes for economy of space even packed edgewise, enabling each case to contain at first as many as 25,000 seed. During the first few months rapid growth renders it necessary to pick out each fortnight and transfer to other cases the largest oysters. This task is carried on at low tide by a squad of women, who at the same time sort out the dead shells and pick from the ground stray oysters. Along muddy river banks their bare feet are shod with great square mud shoes.

As a practical question the culturist is often seriously puzzled to obtain space to plant his cases. He must often make use of the softest river banks, which Americans would look upon as absolutely worthless. He has found that if the surface mud is macadamized with sand and gravel a crust may be formed that will serve admirably for his cultural purposes. The crust is hard to the foot, but jars curiously as one walks heavily upon it. By this costly means miles of bay and river banks are constantly being brought into cultivation. (Plate LXXI, Fig. 1.)

How long the oysters must be allowed to remain before marketing is a question that depends largely upon locality and the length of time they have remained in sub merged cases. Deep parks (Plate LXXIV, Fig. 2) are looked upon with great favor, though they are at times, especially in cold weather, very difficult to properly care for. The lake of Ossegor, seen in the figure, is remarkable for giving its oysters a maximum rapidity of growth, *cf.* p. 377. Case culture should in general prepare the oyster for market during the second season. Winter is the time of the great mortality, and, though ice rarely occurs to any thickness, the oysters are usually kept well below the surface. This end is attained by inclosing the area and retaining, by flood-gates, the

necessary depth of water. Many proprietors, at the approach of cold, remove the cases for storage and repairs, leaving the oysters scattered on the bottom of the inclosures or parks.

An oyster park, accordingly, is an inclosed tract intended to retain tidal water for purposes of culture (Plates LXXIII and LXXIV). It is looked upon as an indispensable aid to the industry. To scatter oysters broadcast in deep beds, as with us, would be especially impracticable in French waters; the oysters would be in constant danger either of *envasement* or the attacks of enemies. It accordingly becomes a matter of economy to construct inclosures that permit the oysters to be guarded and tended, and that give them at the same time the thrifty conditions of warmer water and of littoral feeding. A park may be simply a tract of tide land inclosed by the simplest barriers of planks or of interlaced boughs that serve simply to retain the water for a few hours (Plate LXXIII, Fig. 1). With this view the simple tidal parks are rarely large, perhaps 50 or 100 feet square, to thus give more barriers to hold back the escaping water. In outlining the inclosure, account is taken of expense and of resistance to currents. For the first reason the barrier need be but a foot or two high; for the second, it often requires ballasting with stones. If the current is not a strong one the barrier is constructed in a double line of little fascines. These are of pine or gorse twigs, 10 inches high and 5 inches thick (Plate LXXIII, Fig. 2, and Plate LXXIV, Fig. 1). These stand upright and are firmly implanted, the space between the parallel lines packed with sand and clay, and they form ultimately a wide, low, park margin both water-tight and durable. This inclosure, by keeping the rearing cases continually under the surface, also serves an additional use, considered of great importance in the French localities, that of giving more space for culture, since it brings into use a higher zone of the beach. Should the bottom of the park be not too soft,* it may be thickly strewn with half-grown oysters; the cases then vacant are at once refilled with seed. The *élevage* of the dredged oysters, as we have noted, is of this character; they are simply scattered regularly over the park bottom and allowed to fatten under the thrifty conditions of littoral feeding in warmer water. As a rule, accumulation of sediment does not interfere with culture in these parks. Should the barriers prove not water-tight, a marginal draining trench is naturally formed and the escaping current bears away a great part of the sediment with it.

The more costly oyster parks differ from these primitive inclosures only in the character of their walls. Stone walls, massively masoned, render the structure permanent, while mechanical gates regulate with nicety the depth and renewal of water. An especial use of this kind of park is that of *vivier* for the storage of marketable oysters, especially during the winter season (Plate LXXVI, Fig. 1).

The simplest kind of barrier park is well seen at Cancale (Plate LXXIII, Fig. 1). Here the entire sweep of muddy or sandy shoals may at low tide be seen checkered off in rough inclosures. The barriers that outline them noted in the figure are formed of rough planks well covered with seaweed, held in position by firmly implanted stakes. The center of the park is seen to be drained and the thickly spread oysters are exposed. These parks may be drained at the side by withdrawing a small wooden vane; the collecting sediment is then carried seaward down the intervening alleyway. The

* Mud a foot thick is not regarded as objectionable. The oysters keep readily upon the surface.

oyster's feeding conditions along the flats at Cancale are certainly noteworthy. During my visit the lower sands were streaked and mottled with a golden-brown crust of diatoms.

The second kind of barrier park prevails at Arcachon, by far the most important seat of oyster-culture (Plate LXXIII, Fig. 2, and Plate LXXIV, Fig. 1). The first figure shows one of M. Dasté's parks. The fascines of twigs seen banking the inclosure have been implanted in the hard sand of a little emerging island, a *crassat*. The park bottom is hard, and for that reason draining trenches are not formed. About 10 inches of water is retained to cover the oysters. The other figure represents the employés at work and shows the way in which the small parks are grouped. One of the curious features of Arcachon is a boundary fence, formed of waving saplings, a device intended either to frighten away injurious fishes or to retain them as the tide falls. An illustration (Plate LXXV, Fig. 2) shows the sapling fence on either side of an alleyway, imposed by law, separating adjacent parks, to serve for transport. The oyster boat of Arcachon (Plate LXXV, Fig. 1) is the ancient *pirogue* of the Basque region, often provided with lateen sails—half dory, half gondola—a capacious affair, heavy in build, but curiously light to handle. At the boundary of each park is located a guard boat or *ponton*, one end of which contains the guard and his dogs; the other end serves as a workshop.

An illustration (Plate LXXVI, Fig. 1) shows the character of the most costly type of oyster park, a lake surrounded by well-slanted stone walls. It is the *bassin des chasses* at Sables d'Olonne, half of whose area of 160 acres is devoted to oyster-culture. As a park it illustrates several novel points well worthy of discussion. It is, in the first place, a compound or coöperative park; that is, it includes a myriad of smaller parks and has an organized management. Its central government, supervised by the ministry of marine, regulates the important matter of water supply and rents out tracts to the culturist. This annual rent, about 2 cents per square foot, is understood to include the general expenses of water supply, guards, and necessary repairs. The parks are for *élevage*, the greater part of the seed coming from the region of Auray. The planted beds remind one curiously of those of a market garden, well banked and separated by trenches. These serve to collect the depositing sediment conveniently for removal. The bottom, however, is naturally level and hard, a firm mixture of sand, mud, and clay. This large park again illustrates the principle spoken of in regard to Breneguy, that a large surface allows the water to aërate without constant renewal. The management permits change of water during only three days consecutively per week. The great gates are first opened to allow the water to pass out until only about a foot of water remains above the oysters; the rising tide is then admitted to the depth of 4 to 6 feet and the gates are closed. The water is comparatively shallow and becomes warmer; germination and growth of plant life speedily ensue and furnish the best of feeding to the inclosed oysters. This is attested by the rate of growth and fattening that the oysters are here remarkable for, a *pousse* sometimes as great as half an inch per month. The culturists themselves note that if the water is shallow and warm the growth of the oysters may be forced as that of the plants in a hotbed. There is danger, however, that the water, if shallow, might become too salt by reason of evaporation, or too freshened by reason of continued rains, and therefore a depth of 4 feet is normally maintained. Aëration and living conditions become then so per-

fect that the water of the basin has been left a month without endangering its inmates. For rapid growth, it is found best not to place the oysters too thickly, a maximum of fifty per square yard. The water (sp. gr. 1.026+) is practically that of the sea, the bottom containing no springs and there being no ingress of little streams. Hence, to avoid too great a density from evaporation it is deemed advisable to renew the water more frequently than otherwise required. It is probably on account of the extreme saltness that production can not be attempted. I have personally no doubt that, if it were practicable to temper the density of the lake by a careful introduction of freshened water, and to maintain it at the specific gravity of Breneguy, production might be both possible and profitable.

CLAIRES: SPECIAL PROCESSES, SUCH AS "GREENING" OR PREPARING FOR TRANSPORTATION.

On either side of the great lake at the Sables extend meadow and marsh lands, suited for salt-making. Here have been formed, by means of turf-covered banks, rectangular pond-basins (50 by 150), arranged to be occasionally filled from the lake without (Plate LXXVI, Fig. 2). Our oystermen would be surprised that oysters could be kept alive, much less grown or fattened, in such small and muddy salt ponds. They are nevertheless the *claires*, famous for fattening the oyster or for giving it a color or special flavor. The bottom of the pond is like a plowed field, perhaps slightly more clayey; the sloping sides are turfed to the water's edge. The water, maintained at the depth of but a few feet, is naturally muddy and continually causes sediment, which would be of extreme detriment if the pond basin had not been arranged with a marginal ditch into which all sediment shifts, convenient for removal. It will be seen that the *claire* will be advantageous, yet at the same time dangerous to the oysters. They become continually coated with mud; the water, renewed but once a week or fortnight, is malaërated, and the mortality is of course great. On the other hand, everything conspires to give the conditions for the richest feeding; the minute plant-life that enters the *claire* is forced into luxuriant growth by warm and food-bearing waters, that are slightly freshened by surface drainage. At the Sables differences in temperature between *claires* and outside lake are from 5 to 8° F.; in specific gravity the differences are from .001 to .002. There may naturally be all degrees of *claires*, small and large, some renewing their water every few days, others but a few days each month. It is the exuberant growth of the oyster that makes *claire* culture profitable. In special localities entire *élevage* would not be practicable on account of the rate of mortality. The oysters when grown are simply introduced in the *claires* for several weeks to give them an esteemed taste or color.

Claires must be studied at Marennes, a locality long known to produce oysters green or bluish-green in color and deemed exquisite in taste. Green oysters have become synonymous with Marennes, their reputation, if not their flavor, commanding a high price in the market. Nowhere else along the French coast are found conditions as favorable for *élevage* as well as for "greening." The low-lying tide lands, clayey, but rich in peaty mud, produce the richest of oyster food, clouding the slow waters with minute plant life. Of these low organisms, by far the greater number are diatoms, a race of minute, single-celled plants that often possess a curious power of navigating about apparently at will. They are transparent, incased in a delicately fretted

shell of glass, and contain a number of pellets of golden-brown coloring matter. An exceptional diatom, *Amphipleura ostrearea* (Gr.), contains a green pigment and is nowhere as abundant as at Marennes. The oyster feeding upon it, stores away, first in gills and then in mantle, the vegetable coloring. The green color is said by the connoisseur to give the oyster an inimitable and exquisite flavor, as if savored with mushroom or truffle, an idea which the culturist, however skeptical, is not apt to refute. With a view to higher market price, he has even studied astutely how to give his products the maximum degree of color in the least time. He early attributed the cause of coloration to the myriads of green diatoms, which he termed "moss," and discovered that this moss developed most readily in muddy basins where the water was seldom renewed. The low regions of swamp and salt meadow, often for a mile on either side of the Soudre, has now been built into *claires*, drawing water from intersecting canals (Plate LXXVII, Fig. 2). The *claires* nearer the river may readily renew their waters every few days, offering the better conditions for *élevage*. The *claires* situated upon the uplands, where rapid greening takes place, can only be refilled a few days monthly, in accordance with the lunar tides, and their shallow stagnant waters are therefore most dangerous to the oysters. I am told that here the mortality may average 50 per cent, even though under favorable conditions the oysters will green in a fortnight.

The *claires* at Marennes are established as follows: They are crowded together, separated only by low earthbanks, are small in size, the largest perhaps 75 by 100 feet (Plate LXXVIII, Fig. 1). The bottom is of soft, light-brown mud, banked up in the middle; the marginal trenches are deepest at side, draining into the canal. The drain-pipe piercing the low earthbank is usually a bored pine log, a foot in diameter. The drain-stoppers are like a mallet, removed conveniently from above by means of the handle. In the best development of the green moss the *éleveurs* believe that the *claire* bottom should, like a cultivated field, be annually broken and "freshened up." Early each spring, when the green moss is beginning to disappear, the ponds are emptied. After several weeks the bottom becomes seamed and cracked by the heat of the sun; the trenches are now deepened, the upturned soil so disposed as to give the bottom a mound-like appearance; the basin may even be spaded up as if for a flower bed. In August the water is again permitted to enter, at first but little at a time, allowing the crust to slowly deliquesce, a stage that often produces a froth-like appearance. A week later the *claires* are filled so as to allow about a foot of water to cover the oysters. Late in August the green begins to appear, first in the low *claires*, then in the higher ones; in November it is at its height, the entire basin becoming literally moss-covered. Warmth is naturally essential to rapid greening, the shallow waters varying from 3° to 12° F. higher than margin of the Soudre (August 26 to 28). The slight freshening of water caused by the rains in September and October is also considered of advantage. Springs are absent. The differences in saltness of water of river, canal, low, and high *claires*, are certainly not marked—(73°) 1.023, (75°) 1.0235, (76°) 1.0235, (80°) 1.021 to 1.0225. In value, adjacent *claires*, under apparently the same conditions, sometimes differ most unaccountably in the quantity of green moss that is produced, one *claire* often enabling the oysters to green thrice as rapidly as the adjoining one. For rapid greening it is found best to place the oysters not too thickly, a normal of fifty to the square yard. The oyster's color may entirely disappear if the oyster is allowed to remain for a month or more in other waters, but is not

lost during transport. The green oysters are said, moreover, not only to retain their color, but to bear the fatigue of journeying as well as those raised in tidal parks. Fortunately for the *claire* culture the winter at Marennes is not a severe one, and the only precaution to be taken is to slightly increase the depth of water. More than 2 inches of ice rarely occur.

Before shipment to market two processes may be employed, giving the oyster an additional value to the connoisseur. The first, termed *dégorgement*, frees the oyster from any traces of sand or mud that may have been ingested with its normal food. The second would with us be called *education;* it trains the oyster to bear the fatigues of transport.

Of *dégorgement* but few words need be said. Oysters, especially those that have fattened upon a soft, marly bottom, usually show outward traces of black indigested matter contained in the intestine. The oyster loses these traces of coloring naturally when allowed to remain tranquilly upon a hard bottom in clear water. Cemented or stone-masoned basins or tanks are conveniently employed; the oysters are scattered over the bottom, the water is admitted, and the oysters allowed to remain for a week or a fortnight. (Plate LXXVIII, Fig. 2.) As a rule the basins of *dégorgement* are divided by brick walls into smaller areas of perhaps 25 feet square, enabling one compartment to be emptied without inconvenience to others. A typical basin, seen in Plate LXXVIII, Fig. 2, is at the margin of the Soudre, at La Tremblade, Marennes. The small tramway is one of the features of a French oyster park; the wide platform cars, passing from the shops along the embankment, are found most convenient in transportation.

These basins may sometimes be used for the second process, that of accustoming the oysters to an out-of-the-water existence. The basins may for several days be allowed to fill or empty, according to the tide. It is found, even in this brief time, that the margins of the shells will fit more tightly together and retain the fluids of the oyster for a longer time during transportation. If concreted basins are lacking, the oysters are simply strewn on the shore between tide limits for the same length of time. The shells are finally cleaned, first by a jet of water from a portable hand pump, then by brush or broom. Shells incrusted by *Serpula* or *Membranipora* are scoured with a metal brush.

Oysters are often purchased directly from the *éleveur*, whose duty it is to keep his customers informed of current prices of the different grades and sizes. The oysters are carefully packed in bracken fern by the two, four, or eight dozen, and the box forwarded, express paid, to the residence. A consumer is thus apt to receive the oysters in a perfectly fresh condition. An order, for example, may be left with the agent in Paris at 8 o'clock Friday night; this is received at Marennes the afternoon of the following day; and the fresh oysters will be delivered in Paris in time for the Sunday dinner. If thus ordered the prices can certainly not be regarded as exorbitant. The green oysters of the best grade will cost at the home of the purchaser from 1 to 4 cents, while for half of this price may be bought the largest and finest Portuguese.

IV.—THE PORTUGUESE OYSTER.

The Portuguese oyster has taken an important place in French oyster-culture on account of its cheapness. It requires but little care—for that reason is profitable—and there is a growing tendency on the part of the culturists to raise this less-prized species in their poorer parks. Its introduction from Lisbon into France was certainly economical. A cargo of oysters, supposed entirely lost, was thrown overboard in the Garonne near its mouth. In course of time the surviving oysters gave rise to a remarkable bank, similar in every way to those at the mouth of the Tagus.

The habits of this oyster have already been discussed. We have seen, for example, that it differs from the flat oyster in the general angularities of its shell, coarseness in flesh, sex characters, and in its littoral conditions of living. Outwardly it sometimes resembles the coarsest varieties of the American oyster, a likeness which the sailors recognize, misnaming our product the Portuguese oyster of America!

Since its introduction, in 1866, the oyster has been the subject of careful discussion. The culturists first feared that its hardiness and rate of increase would dislodge its weaker neighbor. It was rumored that the species were producing hybrids, that danger was imminent of loss of the valued qualities of the *edulis*, a notion promptly refuted by scientists. The most important discussions were those tending to legally restrict the introduction of the inferior species in regions of production on the ground that the tiles would become covered with its spat.*

Common consent, however, rather than legal measures, has kept reduced the proportion of Portuguese oysters and has diminished the chances of the less profitable production. Artificial production is as yet crudely developed, since attention is naturally directed in the line of greater profit.*

As with the American species, the fry is hardy and attaches readily. In favored localities the annual production is remarkable, especially near the line of low water, the spat covering pebbles, rocks, sandy beaches, even seaweeds. Collection is often a general one, and is sometimes the principal industry of the poorer class of fisher people. One of the regions naturally favored is Rocher de Der, where it is only at the lowest tides of the month that the great flat rocks are exposed. It is then a curious sight to see as many as a thousand people, men, women, and children, engaged in detaching the oysters. The recult is placed for *élevage* at a slightly higher level in small parks given by the state. The loose stones of each inclosing wall, though thickly covered with seaweeds, are found profitable collectors and are annually overhauled.

* *Vide* List of Works, 51, 55, and 9, *c*, *d*, *e*, *f*.

V.—GENERAL CONCLUSIONS.

In France all attempts to introduce the American oyster have naturally failed, owing, as before noted, to the greater saltness of water. This condition not merely prevents the process of spawning, but changes entirely the character of the animal. The French have a general and very depreciatory idea of the American oyster, just as our compatriots, when traveling, are wont to look upon all French oysters as "coppery and colored with verdigris." Our oyster is classed as a Portuguese, larger in size and inferior in quality on account of lack of parkage.* They can not believe that we have varieties of oysters, small, white, and smooth of shell, whose flavor we would prefer to that of the most exquisite of Belon or Marennes.

The methods of oyster-culture employed in France must be carefully considered in regard to how we ourselves may profit by them. A number of their ideas appear undoubtedly quite pertinent to the needs of our culture. Others must require careful experiments to demonstrate how far they will succeed if transplanted.

In regard to seed production, the principles will prove true with us, but unfortunately there is a stumbling-block on the practical side. With the high price of labor, will production pay? This is a question which I am yet inclined to answer affirmatively. The French pay in general 50 cents per day for their labor. But it seems possible that workers, better paid and of a higher degree of activity and intelligence, might in the end be not far more expensive. The French have many expenses which we would not have to encounter, yet their production is profitable. I have even heard proprietors talk of supplying seed for the American market, a business affair which they regard as practicable, even with the great expenses and losses of transportation.

It is certain that if we can, in favored localities of production, obtain as a steady average two hundred oysters per tile, the seed oyster industry might readily be profitable in spite of everything. As a collector it will be doubtless difficult, for the reasons above given, to find better than the tile. The Portuguese oyster, however, is said to affix more readily to rocks than tiles, a suggestion to be carefully weighed, on account of the kindred habits of the American oyster; but I am strongly inclined to take the opposite view, after a careful examination at Rocher de Der of the rock and tile fragments that had taken the set side by side. With us the common tiles can be manufactured almost as cheaply as in France; and as the annual breakage is but 5 per cent the loss can not be regarded as great, especially as tile fragments may again be utilized. *Détroquage*, moreover, which appears toilsome and expensive, is in reality a simple affair, the oysters peeling from the tile, even with a thrust of the finger-nail. It would be a most important point in the development of our industry to consider, as the French have done, the raising of seed in regions naturally favored, with a view to thus supplying the entire coast. This would not be impracticable. The two centers of production, Auray and Arcachon, supply the coast of France, and often the foreign market; while with us it would not be difficult to select a number of localities noted for seed oysters in almost every Atlantic State. If production will pay sufficiently to

* *Vide* List of Works, 9 *a*, 49, and 9 *a*, 117.

warrant a dozen collectors, the same locality would certainly be far more profitable if collectors were established by myriads. A plan, neither costly nor difficult, would be to experiment with a few collectors and determine expenses of production. We may then compare the rate of cost with the market price of seed as now obtained. First expenditures would naturally be at the maximum; that is, for collectors and labor yet unskilled. At the outset, for example, a collector of 150 tiles might cost $3; but, should collectors be subsequently manufactured in number, the price might readily be reduced one-half. We should not forget that these collectors are said to last a generation, if one-tenth of their first cost is expended in annual tarring and repairs. Each collector should with us produce 15,000 seed; there remains but to find what will be the total cost of production.

The rearing case should be most strongly recommended at home. Without it the French industry would be impracticable; it is as important a factor to their cultural methods as the tile itself; it protects the delicate seed against its many enemies; it keeps the oyster just high enough from the ground to protect it against shiftings of mud or sand, and gives it at the same time the best conditions for rapid fattening and growth. Our oysterman at present purchases his bushels of seed and strews them over his ground below 2 fathoms of water; in the course of time he rakes them up and finds their mortality a very great one, due to many causes, ravages of crab, drill, and starfish, shiftings of sand or mud. Occasionally he loses his entire harvest. If by cases he can succeed in raising for market 80 per cent of the seed, he will in many localities find it to his interest to invest labor and capital in this kind of culture. Each case costs in annual repairs less than 50 cents and should rear at least 500 grown oysters. Its price, which in France is about $3, should be, if anything, less with us on account of cheapness of wire gauze and wood. In quantity, by machine manufacture, the total might be reduced to $1.50, including tarring and labor of putting in position. Case culture will, moreover, render of value many tracts which are now useless solely on account of softness of bottom. The labor required in overlooking the cases should not prove a matter of great expense.

The French have great changes in the height of tides during the month, sometimes a difference of several fathoms. These changes either keep their cases too long under water to allow the proper care to be given them, or, worse still, place them too long out of water to suit the oyster's living conditions. It is but natural to infer that the more regular degree of rise and fall of tides should be more favorable to the establishment of both cases and collectors.

In view of our present needs, what is the most important lesson we are to draw from the studies of the French oyster-culture? The most practical certainly seems the action of the Government in reserving oyster-bearing tracts for the purpose of furnishing seed. This prudent restriction has been the safeguard of the entire French industry. Our oyster-grounds are becoming exhausted solely by the enormous drain upon their resources. In general their conditions for culture are as rich as ever. The oysterman has sent to market practically all of his oysters and expects the beds on his neighbor's ground to furnish him with seed. Too often, however, the neighbor has been equally thrifty and has marketed all of his product. The following year both are astonished at the poorness of the set, attributing it to coldness and rain, but they

never think that the deficiency might have been caused by the want of a quantity of neighboring oysters sufficient to furnish the spat. Nor is one to blame for not preserving his oysters to furnish seed for everybody. French political economy has assigned to government the duty of reserving oyster-bearing tracts for the common good, and the Government has studied where these might most judiciously be located so as to profit all alike. The tracts need not be large and would not be of great expense to the State, at any rate as an experiment in a single locality. The grounds would practically take care of themselves; their only expense would be that of a guardian.

If an experimental oyster tract in one locality should prove eminently successful to neighboring seed-culture, a more general legislative action in different States might reasonably follow. The matter would certainly be most heartily seconded by the oystermen themselves.

We should not expect seed to be abundant where oysters are lacking. And our industry may, for many years to come, demand nothing more pertinent to its welfare than State spawning-grounds near centers of oyster-culture.

The waters of the oyster-grounds of the French coast.—A table of densities for comparison.

	Locality.	Date.	Specific gravity.	Temp.	Specific gravity reduced to 15° C. standard.	Remarks.
				°F.		
1	Cancale	Aug. 6	1.025 -1.0258	74	1.0263-1.0271	
2	Roscoff	11	1.0252	73	1.0263	At marine laboratory.
3	Belon	13	1.0235-1.0252	75	1.0249-1.0266	Margins and middle of river.
4	Lorient	15	1.022 -1.0225	74	1.0233-1.0238	In rearing parks (M. Charles), 1.024(75°)—1.0245(75°).
5	Auray	16	1.0225-1.023	67	1.0227-1.0232	Margins and middle of river.
6	Breneguy	17	1.021	71	1.0218	In basin of production.
7	Trinité	18	1.023	66	1.0230	
8	Sables d'Olonne	23	1.024	68	1.0243	*Claires* about 1.023—1.0235(74°).
9	Marennes	26	1.023	73	1.0241	Cf. p. 379.
10	La Tremblade	27	1.023 -1.024	76	1.0246	Do.
11	Arcachon	Aug. 29 to Sept. 5	1.0185-1.0245	69-78	1.0189	During my visit I had opportunities of taking densities in many parts of the basin. Lowness in specific gravity is surprising, since the idea is very general that its saltness is greater than that of the Mediterranean. As my densimeter was made and tested especially for this work, I feel confident of my results. The same instrument served for all localities and the densities are relatively just. The greatest density is naturally found in the inlet and main channel. The saltness in the regions where production is most favorable was 1.019—1.021 (about 72°). The least densities were found in the N. and E. parts of the basin, due to influx of a number of draining streams.
12	Ossegor	Oct. 7	1.0245-1.0255	64-66	1.0242-1.0255	

LIST OF WORKS RELATING TO FRENCH OYSTER-CULTURE.

[The most important for practical study are indicated by bold-faced type.]

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98. WINKLER, T. C.: Over de oesterfokkerij, het aanleggen van oesterbanken, enz. en over de zeesterren Naar het Deeusch en het Fransch. Sijthoff: Leyden, 1861.

In a majority of cases the sexes are separate, but hermaphroditism exists in very many forms. Pelseneer points out the fact that it exists in isolated forms, species in certain genera, as in *Ostrea*, *Pecten*, and *Cardium*, and whole genera in certain families, as in the case of *Cyclus*, *Pisidium*, and *Entovalva*. He says: "Chez tous ces animaux la glande génitale *elle-même* est hermaphrodite; elle produit dans toute son étendue des œufs et des spermatozoïdes, ou bien si une partie est spécialisée pour donner naissance à chacun de ces produits, ceux-ci sont amenés au dehors par une seul canal, *hermaphrodite* (*Pecten*)."

The European oyster, *Ostrea edulis*, is hermaphrodite, but in the American form, *O. virginiana*, the sexes are separate. While rearing the young of this form from the eggs at Woods Holl, with Mr. Harrison of the Johns Hopkins University, we found a specimen apparently containing both eggs and spermatozoa. On sectioning parts of the generative gland, I found it to be hermaphrodite, as was suspected. The large follicles (Fig. 72, Pl. LXXXIX) were generally more or less united, and their lumens everywhere, in specimens taken from a number of different parts of the glands, appeared full of ripe spermatozoa. The ova, with their distinct nuclei, were apparently unripe, though many were free from the follicle walls. The majority of them were yet attached. The cells of the follicular epithelium showed ova in all stages of growth, and none of them, apparently, were giving rise to spermatozoa.

This specimen was obtained late in June, near the end of the breeding season. Whether or not its sexual glands indicate the change in function from male to female or from female to male, which possibility has been suggested for some lamellibranchs, I can not say; but, as abnormal hermaphroditism often occurs in all groups of animals, this may be an example of it.

The sexual gland of *Pecten irradians* is hermaphrodite, and there are an ovary and a testis on each side of the visceral mass. Both glands are ventral to the liver (Fig. 44, *g*) and have a spongy appearance. The testis is the more ventral of the two and is of a cream color. The ovary, situated above this, has a reddish hue, which is very marked in the living animal.

Fig. 71 represents a section passing vertically through the outer wall of the visceral mass, where the testis and ovary are closely apposed. The body wall is represented at *ep* and consists of a single layer of columnar, ciliated, epithelium cells, whose nuclei are about equally distant from their outer ends and the thick basement membrane (*bm*). In this epithelium are many conspicuous gland cells (*glc*). Between it and the follicles of the generative gland is a thick layer of connective tissue, extending in between the follicles. The follicles of the ovary (*ov*) are not so regular in outline when seen in section as those of the testis (*t*). The walls of the latter bear a follicular epithelium (*fep*). In the ovary, the cells of this layer are in all stages of development into eggs. The eggs themselves, crowding the follicles, possess a very thick egg membrane and their protoplasm is finely granular. A duct from the follicles is seen at *d*.

The mother cells of the spermatozoa (*fep*) are circular and of constant size in the follicles of the testis (*t*). As we follow the mass of cells inward from these mother cells they become very gradually smaller and smaller, until their final divisions result in the spermatozoa. These are so arranged that their "tails," in forming, project in extended masses toward the lumen of the follicle and give it a radiating appearance.

FIG. 1. TREHENNARVOUR, NEAR AURAY. THE COLLECTORS OF WOODEN TRAYS (PLATEAUX).

The entire region seen in the figure was originally a shifting mud flat. It is now entirely reclaimed for purposes of culture by being macadamized. The dark line in the left background is a breakwater. (Page 371.)

FIG. 1. AURAY. DÉTROQUAGE. WORKERS ENGAGED IN SEPARATING THE SEED OYSTERS FROM A TRAY COLLECTOR.

At the left will be seen the side of the lighter used in [illegible] (Page 611), from which the [illegible]

FIG. 2. CANCALE. GUARDIANS OF BEDS AND CANOE FOR HEARING SEED OYSTERS. (Page 390.)

FIG. 1. CANCALE. THE BARRIER OYSTER PARK.

The water is seen slowly draining seaward, allowing the oysters in the higher parts to become exposed. The sides of the park are simple plank barriers. To the left are cases of élevage, well raised from the ground as a protection against shiftings of sand. (Page 376.)

FIG. 2. ARCACHON. AN OYSTER PARK WITH LOW BANKS OF FASCINE AND CLAY.

Cases of élevage are inclosed. The case covers are seen held open by propping sticks while the oysters are being sorted. The embankment separating the ponds are here composed of brush bundles, clay, and plank. The sand flat in the background is covered with Portuguese oysters (Page 376.) Park of M. Dasté.

tissue layer (*ct*). The transparent, irregular cells composing the main body of the palp, and extending into the folds, are the same as those found in the mouth and walls of the visceral mass of *Ostrea*, and described by Prof. Brooks (No. 3) as fat cells.

Fig. 63 is taken from about the middle of the palp. Here the folds are more narrow, and the irregular secondary folds on the side of the primary folds have given way to one regular secondary fold (*sf*). In Fig. 64, a section close to the attached border of the palp, the folds are very regular in size, and without secondary ridges.

The palps of *Pecten* are peculiar in having upon their free edges near the mouth a number of projections which are extremely convoluted and give the appearance of a heavy fringe, part of which is indicated in the palp just anterior to the mouth at *fr*, Fig. 43, Pl. LXXXV. Fig. 68, Pl. LXXXVIII, represents a small portion to show the nature of this fringe. The small figure at the right (A) represents a large branch, whose base is continuous with the free edge of the palp near the mouth. The trunk of this tree-like mass is not solid, but is merely a thin sheet of palp tissue whose surface nearest the mouth is concave. The outer surface shown in the figure is convex. A section across it would be somewhat crescent-shaped. Fig. 68 (B) represents a part of the extreme tip of the fringe more highly magnified. Here the concave side of the mass is presented, and it shows that the whole fringe is made by flat, sheet-like outgrowths of the edge of the palp. The edges of these flat projections turn inward toward the mouth. These edges seem to have grown a great deal more rapidly than the interior of the sheet, and have thus been forced to convolute themselves greatly, as represented in the figure.

A section through the ends of this fringe shows an epithelium made up of very much elongated, ciliated cells (Fig. 75, Pl. XC, *ep*), whose nuclei are arranged in quite a definite row in their outer third. At many points in this epithelium are found groups of large gland cells (*glc*). At the base of the cells is a more or less definite basement membrane (*bm*). Running through the compact tissue of the fringe are blood vessels whose flat, bounding endothelium is plainly seen (*bv*).

The labial palps take food collected upon the gills from the anterior ends of the latter, and by the cilia pass it on into the mouth. The movement of food particles here does not seem so rapid as upon the gills, and its path seems much less defined than the latter. This is easily seen upon the palps of *Yoldia*. The long, ciliated palp appendage of this form with its convoluted borders is similar to the fringe about the mouth of *Pecten*, though situated at the posterior end of the palp. The appendage in *Nucula*, like that of *Yoldia*, is supposed by Mitsukuri (No. 13) to serve in collecting food, and the mouth fringe of *Pecten* in all probability has a similar function, the products of its gland cells cementing the food particles together as on the gills, and its ciliated epithelium passing this on down its concave inner surfaces to the mouth.

The œsophagus.—In the *Nuculidæ*, Pelseneer (No. 17) has described in the buccal region of the digestive tract a transversely enlarged glandular portion, called the pharyngeal cavity. It occurs in no other lamellibranch, but he thinks is homologous with a cavity found in other mollusks—*Patella*, *Fissurella*, *Haliotis*, and *Dentalium*.

The œsophagus proceeds nearly vertically upward to the stomach. It is very large in *Pecten* (Fig. 43, *mo*), smaller in *Mytilus* (Fig. 33) and *Venus* (Fig. 10). Its opening into the stomach is generally somewhat funnel-shaped, but in *Mya* is abrupt, with a definite muscular opening.

FIG. 1. ARCACHON. THE OYSTER BOAT.
The fringe of waving saplings in the background are seen in detail in the second figure. (Page 377.)

FIG. 2. ARCACHON. AN ALLEYWAY FOR TRANSPORT, PASSING BETWEEN NEIGHBORING PARKS. IT IS MARGINED WITH SAPLING FISH-DEFENDERS. (Page 377.)

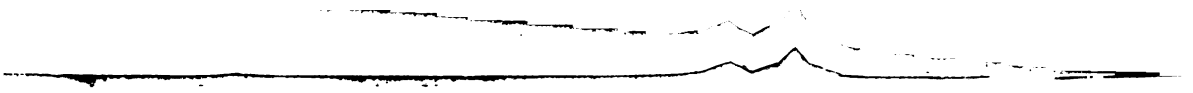

FIG. 1. SABLES D'OLONNE. VIEW OF GREAT BASIN OF ÉLEVAGE TAKEN FROM NEAR THE SLUICE GATE.

The claires, Fig. 2, are situated on the low meadows alongside. The end of the lake in the distance furnishes the water for salt evaporation. The white points seen in the figure are large heaps of salt. (Page 377.)

FIG. 2. SABLES D'OLONNE. A VIEW OF THE CLAIRES TAKEN FROM THE MARGIN OF THE GREAT BASIN, SHOWING THE HEIGHT, WIDTH, AND CHARACTER OF THE EARTHEN BANKS THAT FORM THEIR OUTLINES. (Page 378.)

In *Nucula* and *Arca* the ventricle has the appearance of being double; that is, with distinct right and left halves. This has given rise to a discussion as to its meaning. Milne-Edwards (No. 12) regards it as the primitive condition, pointing to a double origin of the heart. Grobben (No. 6) considers the single heart as the primitive one and believes that this double condition has been brought about by the forward extension of the foot-retractor or byssus muscles. Theile (No. 22) believes that the heart was originally of two independent halves and that upon uniting in the median line the heart is found in its various positions, inclosing the rectum or lying above or below it. His conclusions are based on the fact that Ziegler (No. 24) has shown the pericardium of *Cyclas* to be formed in development from two symmetrical vesicles which unite in the median line. At about the same time that Theile's paper, above referred to, appeared, Pelseneer (No. 17) expressed the opinion that neither the views of Milne-Edwards nor those of Grobben were altogether correct. He discards the view of the latter entirely. He says that this double condition is not absolutely primitive, but is "due to the bilateral separation of the gills (much closer to one another in other lamellibranchs) and the auricles." The primitive heart, he believes, was dorsal to the rectum, and the commonly perforated heart was formed by a fusion of the two parts of its ventricle below the rectum. In *Ostrea*, when the heart is ventral to the rectum, this position was acquired by the great development of the single adductor; for, as it extended so greatly dorso-ventrally, it carried down the gills, and with them the auricles. These, not elongating, also compelled the ventricle to move downward. I had myself already come to this conclusion in regard to the peculiar position of the heart of *Ostrea*.

The pericardium is generally a large space in which the heart lies. Its relative size varies extremely, however, in different forms which may be closely related. For instance, the pericardial space of *Mya arenaria* (Fig. 27, *p*) is quite small, while in *Venus mercenaria* (Fig. 16, *p*) it reaches a very great size. Lacaze-Duthiers showed that the heart of *Anomia* did not lie in a pericardium, and he believed that none existed. Pelseneer, however, thinks that he has found the remains of the pericardial space in a flat cavity beneath the rectum, into which open the inner ends of the kidneys. The pericardium is not connected with the vascular system, but into it open the excretory organs, one on either side, and, when they are present, the pericardial glands.

In most cases the heart of a lamellibranch gives off an anterior aorta which runs forward above the rectum, and a posterior aorta proceeding below the rectum. In some forms, however, the posterior aorta does not appear. Such an exception is *Solenomya*, one of the most primitive forms.

It has been claimed that the possession of two aortæ was the primitive condition and that when the posterior one was absent it had degenerated and disappeared. As the general relations of such a form as *Solenomya* have become known they have shown that it is a primitive form; and, as it possesses but one aorta, that condition may have been the original one in the group. In the gasteropods there is no posterior aorta, but a branch of the anterior aorta supplies the posterior part of the body. The remaining groups of the Mollusca have both anterior and posterior aortæ. Pelseneer (No. 17) considers the single aorta the original condition in lamellibranchs.

As has been said, the oyster possesses both anterior and posterior aortæ. The former springs from the upper (morphologically anterior) end of the ventricle and

FIG. 1. MARENNES (LA TREMBLADE). VIEW OF THE CLAIRES FOR FATTENING THE OYSTERS

The draining and feeding canal communicating with the large canal of the [illegible] planks. The picture shows clearly the flat character of the country, the [illegible] and the way in which the establishments are crowded together. Each [illegible] of adjoining claires. (Page 379.)

15.—A CONTRIBUTION TO OUR KNOWLEDGE OF THE MORPHOLOGY OF LAMELLIBRANCHIATE MOLLUSKS.*

BY JAMES L. KELLOGG, PH. D.

At the direction of Hon. Marshall McDonald, U. S. Commissioner of Fish and Fisheries, I undertook the following work at the Fish Commission station, Woods Holl, Massachusetts, during the summer of 1891, and while there enjoyed the kindly interest of that gentleman, as well as many attentions shown me by Dr. H. V. Wilson, then biologist in charge. I am also much indebted to Dr. E. A. Andrews, of Johns Hopkins University, for aid and advice. I wish to express my appreciation of the attention and counsel given me by Prof. W. K. Brooks while engaged in this work.

Before I began the work it was pointed out to me by Prof. Brooks, of Johns Hopkins University, that the study of lamellibranch anatomy had been carried on almost entirely by means of dissections, which are difficult to figure or describe satisfactorily, and that comparatively little use had been made of sections. I hope to show not only that the anatomy of a single form may be easily described by this method, but that the comparative anatomy of various forms may be readily demonstrated.

It is interesting to notice, in connection with this use of sections, that the great amount of labor required in producing such a work as Deshayes' Atlas, Mollusques, has been of little service. It is a very large volume of beautiful plates representing dissections; but, even if they had been properly described, the comparison of special organs of different forms would have been very hard to understand. The cost of such a work also renders it inaccessible.

Unfortunately I have been able to obtain but very few representatives of this group of mollusks for examination, and consequently do not feel able to attempt very wide generalizations. Since the completion of the present work a full and valuable paper by Prof. Paul Pelseneer (No. 17) has appeared, dealing principally with forms other than those here discussed. Much has yet to be done in comparative studies in this group, notwithstanding the great works of Lacaze-Duthiers and others.

* The principal species of marine bivalve or lamellibranchiate mollusks treated of in the present paper, which the writer has examined personally, are eleven in number, including six forms of greater or less economic value. The structure of other marine species and of the fresh-water mussels *Unio* and *Anodon* is also discussed. The eleven species first referred to are as follows: *Mya arenaria* Linné (common long clam); *Mactra solidissima* Chemnitz (sea clam); *Venus mercenaria* Linné (quahog); *Venericardia borealis* Conrad; *Solenomya velum* Say; *Yoldia limatula* Say; *Arca* (*Argina*) *pexata* Gray; *Mytilus edulis* Linné (common mussel); *Pecten irradians* Lamarck (scallop); *Anomia simplex* Verrill; *Ostrea virginiana* Lister (oyster).

A number of elementary anatomical facts are here very briefly mentioned in order to make the explanation of sections illustrating the general anatomy intelligible to those not already well acquainted with it. They are also of use in explaining a number of scattered observations of my own.

THE SHELL.

The outer covering or shell of lamellibranchs is made of an organic base, impregnated by lime, which is taken from the surrounding water. Osborn (No. 14) and others have shown that the mantle lining the shell valves on their inner faces secretes a soft, gummy substance, which soon becomes tough and is finally completely filled with spicules of carbonate of lime. In the oyster, examined by Osborn, no prismatic or mother-of-pearl layer is formed inside this, as is the case in many other forms. The varying proportions of lime make a great difference in the resisting power of the shell. In the shell of *Mytilus edulis*, the common mussel, there is but little lime, compared with the tough, horny basis, and as a result the shell is strong and unyielding. The shell of *Venus mercenaria*, the "little-neck clam" or "quahog," as it is often called on the Atlantic coast, is, on the other hand, made almost entirely of lime. Though the shell is thick and heavy it breaks into many fragments, like a piece of porcelain, when struck a severe blow. The thickness of the shell of many lamellibranchs depends greatly upon the amount of lime held in solution by the water in which it exists.

It is characteristic of this class of the Mollusca that the shell is made of two independent halves, called valves, which are joined to each other by a ligament. This is tough and rubber-like, and between it and the concavity of the shell is the hinge, where the valves, in touching each other, form a fulcrum. In many cases one valve is hollowed out at this point and the other has a corresponding projection, or perhaps many of these, each fitting into a hollow. These relations may be seen in Fig. 96, Pl. XCIV, where *lg* is the ligament and *hg* the hinge. The adductor muscles (*aa* and *pa*), on contracting and closing the shell, cause, through the action of the fulcrum at the hinge, a stretching of the ligament. When these muscles are again relaxed the ligament contracts automatically, as would a piece of rubber, and opens the valves at the opposite extremity.

In the oyster there is no distinct hinge, but the ligament is made of two parts, a central, thick, and elastic portion (Fig. 97, Pl. XCIV, *lg*), and above and below this a slight ridge. The shell projects slightly at these points and may help in functioning as a hinge. The valves of the shell are generally equal to one another in size and shape. In the oyster the left valve is the larger one; it is much heavier and is sufficiently hollowed out to contain the whole of the soft parts (Fig. 97, Pl. XCIV), while the right valve is smaller and almost flat. The animal is attached by the former.

The outer surfaces of the shell are generally marked by concentric lines of growth, and along its edges may be found the horn-like cuticle, secreted by the mantle edge. This cuticular covering of the outer surface of the shell is often thin and may be lost, except at the edges. In the case of *Solenomya* it is very thick, covering the whole shell from sight and extending some distance below its ventral edge. The umbo, a rounded prominence on the dorsal side of many shells, is well marked in *Venus* (Fig. 96, Pl. XCIV).

Internally the valves are white or colored in various tints. In some cases the coloration is due to pigment in the shell substance, in others to the refraction of light by the striated prismatic surface. In the former case, when the color is bright, it may fade at the death of the animal, as I have seen it do in certain species of *Unio*.

The positions of the attachment of the adductor muscles to the shell are indicated by glossy, more or less oval areas, which are sometimes, as in *Ostrea* and *Mytilus*, darkly colored. Very often (*Venus*, *Mya*, *Mactra*, etc.) a line of the same glistening appearance runs along near and parallel to the ventral border of the shell, joining at either extremity the adductor muscle scars. This pallial line generally folds inward posteriorly in those forms possessing siphons, making a deep loop into which they may be retracted. The mantle edge is attached to the shell, though not very firmly, throughout the extent of the pallial line.

The shell has sometimes been made the chief or only basis for the classification of the members of the Lamellibranchiata. But a single organ is a very unsafe basis for the comparisons needed in such a case.

ADDUCTOR AND RETRACTOR MUSCLES.

The adductor muscles connect one valve of the shell with the other and are generally very conspicuous. In order to open the shell these must be cut away from their connection with it. Each adductor is generally made of two kinds of fibers, one being of a darker shade than the other. The darker portion of the muscle is generally interior to the lighter, and is in some cases larger, in others smaller, than the latter. The former condition is shown in *Venus* and *Ostrea* (Figs. 96 and 97, Pl. XCIV) and the latter in Fig. 47, Pl. LXXXVI, which represents the adductor of *Pecten irradians*, cut longitudinally and vertically. The darker portion, very much contracted, is shown above the more extensive lighter part. It is well known that, especially in the forms of the *Monomya*, this darker portion of the adductor is made up of fibers presenting a striated appearance, which, however, does not correspond to the cross striation in muscle fibers of arthropods and vertebrates. The lighter part of the adductor is made up of plain, unstriped fibers. Pelseneer (No. 17) confirms the supposition that this condition also exists in many forms with two adductors, which he has examined.

This striation of muscle fibers, which has been referred to by many writers as being present in the adductor fibers of lamellibranchs, has not been described in definite terms, but is generally spoken of as an "appearance of striation." So far as I know, it has only been seen in the adductor muscles. I have found in the muscles of the heart of *Ostrea virginiana* a remarkably distinct striation of the fibers. I have not yet had the time at my disposal for a careful histological examination of the nature of this striation, though it promises to be a favorable subject for such study, as the striations are large and not numerous, there being about twenty to .03 millimeters of the fiber. The muscles of the auricles of this heart at least seem to be composed entirely of these striated fibers.

Fig. 65, a cross-section of a portion of the auricle of the heart in *Ostrea*, will give some idea of the nature of this striation. *Sm* represents an apparently homogeneous basement membrane of the many-layered epithelial wall of the auricle. At certain places it makes a loop out beyond the wall (*a*), perhaps gaining some support to resist, in this way, the contractions of the muscle fibers which are attached to its inner

face, though this is very doubtful. These striated fibers (*smf*) ramify, from their attachment to this membrane, in toward the center of the auricle. They are generally in irregular bundles, though not in the sense that the fibers are closely bound to one another. The fibers are very long.

Scattered among them are many single pigment cells (*pgc*), which give the auricle its brown color. Also surrounding the fibers are many cells, apparently of an epithelial nature, which seem to be giving off vacuolated ends (*v*) into irregularly formed spaces, thus having very much the same appearance as the secreting cells of the nephridium. Their nature needs further study.

The functions performed by these two portions of the adductor mentioned above are not well understood. Von Jhering (No. 23) thinks that the part with the plain fibers is used simply as a means of keeping the valves from spreading too far apart on account of the action of the shell ligament. The same view is held by Lankester (No. 8), who does not say, however, which portion he believes to exercise this function. In opposing the view of Von Jhering, Pelseneer (No. 17) says that in the *Pholadidæ*, which have no ligament between the valves of the shell, the adductors are formed entirely of fibers which have no appearance of striation. He thinks that it is probable that, when these two parts exist, "la partie à apparence striée des adducteurs sert, comme chez les autres invertébrés, à produire des contractions rapides."

Although I had made very few observations on the subject, I had come to a different conclusion from any of these. It seems to me that the fibers of the darker portion of the adductor muscles are more compact and firm, and probably supply the greater part of the force required in keeping the shell closed. The fibers of the lighter portion, not being packed so closely together, are able to contract more quickly and close the shell, it may be against a sudden attack. If a valve of *Pecten* be removed, the smaller darker area will be seen to preserve an extremely contracted condition, while the large white part, also partly contracted, now and then makes very sudden and violent contractions, and then immediately relaxes somewhat. These contractions can be made to occur by striking or cutting almost any part of the body besides the adductor, but more especially the mantle edge. The contractions also occur from time to time if the animal is undisturbed. It seems then that a sudden closing of the shell, so often necessary to lamellibranchs, is accomplished by the lighter portion, and that the darker part comes more actively into play when the shell is to be closed for some little time. The lighter portion in *Pecten* is relatively very greatly developed, and, as the very large size of the adductor has been brought about partly for locomotion by its extremely rapid contraction, the lighter part is the one which performs this function. Though other forms do not have this method of locomotion, the manner of contraction of the white and dark fibers may be the same.

The two pairs of foot-retractor muscles are of general occurrence, except in forms with an aborted or absent foot, and are well seen in *Venus*. They are attached to the shell close above the adductors (Fig. 96, Pl. XCIV, *afr* and *pfr*), and join the anterior and posterior parts of the foot, respectively. The anterior ones, which pass obliquely backward from their attachment, are shown cut across at *ar*, Fig. 11, Pl. LXXXI, which is a vertical section in the region of the anterior end of the stomach. In Fig. 12, a little farther back, they are cut more nearly longitudinally and show their final union with one another and the foot, *f*. The same relations are shown for the posterior retractors in *Venus* in Fig. 17, Pl. LXXXII, at *pr*.

The muscle system of *Mytilus edulis* is worthy of re
sents the musculature dissected out entire. From th
rior portion, two cylindrical muscles, called the ante
passing on either side of the mouth (Fig. 33, *ar*), and
shell. They are, in the adult, entirely free from any
and all their fibers are inserted in the base of the by
its concave anterior surface (Fig. 42, *f*), is continued
two cylindrical muscle bundles (Fig. 42, *fm*), which p
muscles just mentioned (Fig. 36, *fm* and *ar*). The
removed without disturbing any of the other muscle
retractors. The byssus organ is morphologically a p
described are probably the anterior and posterior f
the byssus organ has lost all connection with the mu
anterior adductors also.

From the base of the byssus, just behind the ins
extends a great mass of muscle bundles which, attach
and posteriorly, serve as its main support. These b
groups. They are close to one another at the byssu
become attached to the valve of either side. (Show
mass extends obliquely backward and is divided wit
of large bundles (Fig. 42 *bm*). They are shown in th
38 to 40.

A dorsal muscle, well shown in *Nucula* and *Sol*
parallel to the anterior foot-retractors (Pelseneer, No.
ment to the shell is slightly posterior to the latter.
in *Anomia* the byssus muscles, are attached only to

Other large muscles are developed in the mant
region of the siphon, which will be spoken of in that

THE FOOT.

This characteristic organ, appearing generally,
fied, throughout the Mollusca, is in lamellibranch
ventral surface of the main body of the animal. I
In the primitive forms *Yoldia* and *Solenomya*, the lov
forward, and where the organ has degenerated grea
from the extreme anterior end of the visceral mass.
small, though functional in locomotion and situated
and many others, it occupies the whole ventral surf
slightly backward as well as forward, and in a few
heel-like projection posteriorly.

Certain simple and probably primitive lamellib
more or less circular ventral disc (*Pectunculus*, *Nu*
margin of this are a number of thick, short papillæ
representing *Yoldia limatula* with the right valve
the general relations of the foot (*f*). It is seen to
rest of the animal, the mantle being very thin. Th

(the figure having been sketched from an alcoholic specimen), but its position and the marginal papillæ may be seen. When the foot is contracted, as in the figure, the lateral edges of the disc are brought together ventrally, thus making a crease from before backward through the middle of the disc. The disc may be so fully expanded that the crease sometimes disappears, but this does not often happen.

The most usual form of foot in lamellibranchs is that typically shown by *Venus* (Fig. 96, Pl. XCIV). It is flattened from side to side and extends in this case along nearly the entire ventral surface of the visceral mass (*f*). Its anterior end is ploughshare shaped and is greatly protrusible. Instead of being somewhat flat on its ventral surface, it is more or less sharp or heel-like (seen in vertical section at *f*, Fig. 13). In *Mya* the foot is much compressed laterally, and projecting anteriorly to the body, is slightly sharper above than below (in vertical section at *f*, Fig. 23, Pl. LXXXII). It does not extend along the ventral side of the body, or visceral mass, as in *Venus*, but occupies a position more like that of *Mytilus* and *Pecten*.

The foot of *Mytilus* is an entirely muscular, tongue-like organ, flattened dorsoventrally, concave above and convex on its lower surface (Fig. 42 *f*). In *Pecten* it is relatively much smaller, being a short cylindrical projection from the anterior end of the visceral mass. In *Ostrea* and *Anomia*, which are fixed forms, the foot has entirely disappeared.

The foot serves a number of different purposes, but is generally used as a burrowing organ. The end of the foot is protruded as a long, narrow tongue, which digs into the sand with a worm-like movement, keeping the shell closed as much as possible. When it has penetrated to some depth it expands at the end, the retractor muscles come into play, and the whole animal is gradually pulled beneath the surface of the sand. The forms with the ventral disc are very active. *Yoldia*, when burying itself, makes a sharp point of the anterior part of the folded disc of the foot and very rapidly burrows this into the mud. The disc is now widely expanded, forming a firm anchor, the foot-retractors contract and draw the body down to the end of the foot, in this way quickly covering it. *Solenomya* has the same habit, and also often swims rapidly through the water by using its powerful foot as a paddle. It is stretched out anteriorly, the disc opened, and a rapid backward stroke is made. This is repeated with great rapidity. One or two lamellibranchs have the habit of creeping on the ventral side of the foot, as in gasteropods, but, as far as I have observed it, in the adult of one very small form and in the young of *Mytilus* and *Pecten*, it is done in a very imperfect way, the animal frequently being unable to maintain its erect position when crawling over a smooth surface and falling over on its side.

The foot of many lamellibranchs, as that of *Venus* or *Anodon*, is made up of muscle fibers, which are irregularly distributed vertically and horizontally, leaving everywhere spaces which are in connection with the vascular system. Blood being forced into these spaces by the heart, causes the extension of the foot. The general direction of the fibers in the foot is indicated in Fig. 13, Pl. LXXXI, *f*. In this section a sharp separation occurs between the foot and the genital gland above (*g*). Just below this the foot shows many transverse fibers (*mus*). From this region, too, three principal bands of muscle fibers extend down toward the ventral side of the foot. Their contraction, probably, aids the foot-retractors in drawing the foot up close to the visceral mass. Farther back (Fig. 14), in the region of the posterior end of the stomach, the sexual gland forces its way for a considerable distance down between the

more scattering foot muscles. This very generally occurs in forms with this kind of foot. In *Yoldia* and *Solenomya*, also, the sexual gland occupies a considerable portion of the upper part of the foot. The walls of the foot are made of a more dense layer of muscle fibers (Fig. 13).

In such forms as *Mytilus*, where the foot is degenerated and is of little or no use to the adult animal as a burrowing organ, it is not necessary that it should be expanded, and it has almost entirely lost its blood spaces, those only remaining which may contain blood for the nourishment of the tissues of the foot. The fibers are closely packed together, making the foot very dense and tough.

THE BYSSUS.

This organ is generally considered to be a gland of the foot. The byssus itself is made of a number of horny secreted fibers which attach by their outer ends to foreign objects. The part which does the secreting, the byssus organ, occupies various positions in different lamellibranchs. In *Nucula* there is a small blind sac near the posterior edge of the disc of the foot, and Pelseneer has described above this several gland-like cells which he thinks represent the byssus organ. In *Venericardia borealis* a well-developed byssus is present in a slight groove near the middle of the ventral surface of the foot. In *Mytilus* the great byssus has no connection with the foot in the adult, but is situated behind it.

The byssus organ of *Venericardia* is one of the best for examination, as it is not greatly complicated. Fig. 73, Pl. LXXXIX, represents a horizontal section through it. The secreting surface is deeply folded (*fd*), and in these folds the secretion is seen in long sheets (*bs*). Surrounding the folds is a mass of the secretion made of concentric layers, which have been added to its inner border. At the inner ends of the folds are many vertical muscles (*bm*) which are strongly inserted and serve by their attachment to the valves of the shell above as a very powerful support. Among these muscles are many large, almost clear cells (*c*).

Fig. 74 shows the epithelial surface of one of these folds. The greater number of the lining cells approach to a columnar form (*cc*), and appear to be ciliated. At the deeper part of the fold the lining cells suddenly become very large, indistinct (*lc*), and almost entirely unstained. I could make out no nuclei in them. The cells which seem from the appearance of the section to do the secreting, are the epithelial cells (*cc*). The byssus secretion (*bs*) I never found extending down over the large clear cells, but it more often adhered to the other cells as shown in the figure, and was much thicker at the outer than at the inner end. In some sections the dense apparent ciliation of these cells suggested that possibly there was really a striated secretion instead of a ciliation.

If individuals of *Mytilus*, which have been torn from their attachment, are put in a dish of sea water, they soon become again attached.* A very fine, transparent thread appears, and where it strikes a solid body, its end spreads out in a number of root-like processes which form a firm attachment. Soon another similar thread appears and attaches itself, generally at some distance from the first. Though this may take place in a minute or two after the individual is placed in the dish, I was not able to see the exact manner in which the thread was protruded. I imagine, however, that

* Since the above was written, I have carefully observed the method of attachment in *Mytilus*, which is accomplished by the foot, as referred to by Prof. Verrill. An account of it will be included in a later paper.

In the oyster the partition between the two openings in the mantle is permanent, the mantle folds being united. Fig. 89, Pl. XCIII, represents a view of this part of the mantle seen from behind. The mantle folds are fused at *br p*. Above, the upper part of the cloacal chamber is exposed where it communicates with the exterior, and the rectum (*r*) is seen to open into it. Below the fusion, the branchial chamber is seen, together with the posterior ends of the gills (*og* and *ig*), which hang in it.

In *Mytilus* this region is more modified. The cloacal opening, which is small, appears from the exterior to be much more definite (Fig. 87, Pl. XCIII, *co*) and is surmounted by a tough ring, which, like the whole mantle edge in this region, is colored by a deep-brown pigment. Tentacles are here absent from the mantle edge. Ventral to this, the mantle folds do not shut in a complete branchial orifice. Closing the upper part of the space between the mantle folds on the inside, is a thick, pigmented membrane, a part of the mantle (*br m*). This is also shown in Fig. 88, which is a posterior view of Fig. 87. In this figure the extreme posterior ends of the gills mark the partition between the epibranchial chamber above, whose opening to the exterior is seen at *co*, and the branchial chamber below. Thus far there is little indication of a development of much tissue in connection with the siphon-like openings other than that usually present in the mantle edge.

If we imagine that the two separated openings in *Ostrea* and *Mytilus* are made definite—that is, that the branchial passage is separated from the ventral mantle edge by a second fusion—and that they are protruded as tubes, we will have in the main the condition in the siphoned forms (Fig. 96, Pl. XCIV, *sn*). A vertical, longitudinal section through the posterior region of the body of *Venus* (Fig. 93, Pl. XCIII) will show the relations of most of these parts. Below, and to the right in the figure, is seen the branchial chamber (*br c*), in which hang the gills (*ig*). The upper part of the gills, forming the floor of the epibranchial chamber (*ep c*), is seen in the section, and the openings of the water tubes into the latter chamber are indicated. Bounding this part of the epibranchial chamber above is the posterior adductor (*pa*). The epibranchial chamber opens into the base of the cloacal siphon, which also receives the end of the rectum (*r*) from above, it having come down over the adductor. This basal portion of the siphon may perhaps be called the cloaca, though it is small. The lower or branchial siphon opens into the branchial chamber, but at its base there stretches across its whole upper part a membrane (*br m*), occupying the same position as that already referred to in *Mytilus*. If we should take an unsectioned specimen and throw back the mouth folds so as to get a view of the base of the lower siphon from the branchial chamber, we would have the membrane shown as in Fig. 90, Pl. XCIII, *br m*. Extending down from the posterior end of the gills, it covers all but the lower part of the base of the branchial siphon seen below in the figure. It does not extend straight across from one side to the other, but presents the appearance of a deep notch extending upward. On either side of it the bases of the thick siphon walls may be seen.

One might naturally suppose that from its position this branchial membrane would allow water to enter the branchial chamber, but that any back flow would apply it over the base of the branchial siphon; this would prevent the water from escaping, thus acting as a valve. If the animal is able or has occasion to use this fold in such a way, I have not observed it. *Mactra solidissima*, the sea clam, much like *Venus* in anatomical points, has a branchial membrane that apparently completely covers the branchial siphon at its base. But if an individual be quickly taken out of

the water the valves close and the water in the branchial chamber is discharged principally through the *branchial* siphon, so that the membrane must have been raised in order that this might occur.

If the valves of the shell should suddenly close, much of the water in the branchial chamber would escape ventrally. While this is going on, the siphons are being drawn within the shell, and of necessity against this pressure in the branchial chamber, caused by the closing of the shell. If, instead of being closed, the branchial siphon should be opened, and thus allow the imprisoned water to rush out, it would allow their retraction to be more easily and quickly accomplished.

The siphons of *Venus*, however, are small, and do not meet the difficulty in retraction encountered by the enormously developed siphons of *Mya arenaria*, the "long-necked clam," especially as the branchial chamber is here closed below over nearly its entire extent, and allows little water to escape between the mantle edges. When the siphons are contracted—and the process is always comparatively a very slow one—a stream of water is discharged from both, but mainly from the branchial. Though finally brought within the shell, their outer ends are somewhat exposed, as the shell in their region is expanded and its valves can not meet behind them. The branchial membrane is not here present, but may perhaps be represented by part of the thickening in the partition between the siphons (Fig. 94, Pl. XCIII, *br m*). If this is so, the organ may have been lost because of its interference, though it may have been slight, in the laborious process of withdrawing the siphons into the shell.

Just what advantage may be subserved in the forms where the branchial membrane is so greatly developed is not apparent to me.

The series of figures 18 to 22 represents this posterior region of the body of *Venus* in vertical section. Fig. 18 has been cut just in front of the branchial membrane (*br m*) and the posterior adductor is seen above. The mantle edge has become muscular and very thick at *m*, to form, farther back, the walls of the siphons. The bases of these have been cut across in Fig. 19, and it may be here seen how their walls are gradually constricted off from the mantle at *x*. A fold of the mantle (*m*) extends across under the lower siphon and is also present in Fig. 20. In this latter figure the mantle fold is entirely separated from the siphon walls, except dorsally, and these walls are seen to be very thick and muscular, especially those of the cloacal siphon. In Fig. 21 they have assumed a uniform thickness. In Fig. 22 the siphons are cut across where they have protruded backward beyond the mantle edge. The basal part of the lumen of the upper or cloacal siphon (Fig. 19, *ns*) is somewhat triangular in section, while that of the branchial siphon is more nearly circular. Toward their outer end they appear as slits elongated dorso-ventrally, though not to so great an extent in the living animal.

The anatomy of the siphons of *Mya* is much the same as in *Venus*. Fig. 29 is a thick section just before the bases of the siphonal openings. The cloacal chamber is cut across at *cl*, showing the gills at their posterior ends, separating the cloacal from the branchial chamber. The posterior end of the partition between the siphons is seen at *br m*. The muscles, which are to become the siphon walls farther back, are shown at *ws*. These, from this region to the ends of the siphons, are covered by a thick, gelatinous, semitransparent tissue, *ct*. Still farther back, as in Fig. 30, in which section the right side has been cut deeper than the left, are seen the siphon walls on

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tissue layer (*ct*). The transparent, irregular cells composing the main body of the palp, and extending into the folds, are the same as those found in the mouth and walls of the visceral mass of *Ostrea*, and described by Prof. Brooks (No. 3) as fat cells.

Fig. 63 is taken from about the middle of the palp. Here the folds are more narrow, and the irregular secondary folds on the side of the primary folds have given way to one regular secondary fold (*sf*). In Fig. 64, a section close to the attached border of the palp, the folds are very regular in size, and without secondary ridges.

The palps of *Pecten* are peculiar in having upon their free edges near the mouth a number of projections which are extremely convoluted and give the appearance of a heavy fringe, part of which is indicated in the palp just anterior to the mouth at *fr*, Fig. 43, Pl. LXXXV. Fig. 68, Pl. LXXXVIII, represents a small portion to show the nature of this fringe. The small figure at the right (A) represents a large branch, whose base is continuous with the free edge of the palp near the mouth. The trunk of this tree-like mass is not solid, but is merely a thin sheet of palp tissue whose surface nearest the mouth is concave. The outer surface shown in the figure is convex. A section across it would be somewhat crescent-shaped. Fig. 68 (B) represents a part of the extreme tip of the fringe more highly magnified. Here the concave side of the mass is presented, and it shows that the whole fringe is made by flat, sheet-like outgrowths of the edge of the palp. The edges of these flat projections turn inward toward the mouth. These edges seem to have grown a great deal more rapidly than the interior of the sheet, and have thus been forced to convolute themselves greatly, as represented in the figure.

A section through the ends of this fringe shows an epithelium made up of very much elongated, ciliated cells (Fig. 75, Pl. XC, *ep*), whose nuclei are arranged in quite a definite row in their outer third. At many points in this epithelium are found groups of large gland cells (*glc*). At the base of the cells is a more or less definite basement membrane (*bm*). Running through the compact tissue of the fringe are blood vessels whose flat, bounding endothelium is plainly seen (*bv*).

The labial palps take food collected upon the gills from the anterior ends of the latter, and by the cilia pass it on into the mouth. The movement of food particles here does not seem so rapid as upon the gills, and its path seems much less defined than the latter. This is easily seen upon the palps of *Yoldia*. The long, ciliated palp appendage of this form with its convoluted borders is similar to the fringe about the mouth of *Pecten*, though situated at the posterior end of the palp. The appendage in *Nucula*, like that of *Yoldia*, is supposed by Mitsukuri (No. 13) to serve in collecting food, and the mouth fringe of *Pecten* in all probability has a similar function, the products of its gland cells cementing the food particles together as on the gills, and its ciliated epithelium passing this on down its concave inner surfaces to the mouth.

The œsophagus.—In the *Nuculidæ*, Pelseneer (No. 17) has described in the buccal region of the digestive tract a transversely enlarged glandular portion, called the pharyngeal cavity. It occurs in no other lamellibranch, but he thinks is homologous with a cavity found in other mollusks—*Patella*, *Fissurella*, *Haliotis*, and *Dentalium*.

The œsophagus proceeds nearly vertically upward to the stomach. It is very large in *Pecten* (Fig. 43, *mo*), smaller in *Mytilus* (Fig. 33) and *Venus* (Fig. 10). Its opening into the stomach is generally somewhat funnel-shaped, but in *Mya* is abrupt, with a definite muscular opening.

all sides, the whole still within the mantle folds. Fig. 31 represents a section of the siphons at some distance from the body.

The muscles of the siphon of *Yoldia* may be divided into two chief groups: (*a*) transverse and (*b*) longitudinal layers. As far as I know, there are no circular fibers. Small transverse and longitudinal layers alternate with one another to form the siphon walls. Fig. 53, Pl. LXXXVII, represents a transverse section of a bit of the siphon walls in this form, *as* being the cavity of the anal and *bs* the branchial siphon; *ss* is the septum separating them. The transverse layers (*trm*) extend across the walls. Nuclei are present most frequently in the central, narrower portion. At the outer edges of the layers the fibers separate and spread out to become attached. In this region, also, numerous nuclei of the fibers appear. The longitudinal muscles occur principally between the transverse layers (*lm*), but there are also many smaller bundles near the point of attachment of the transverse muscles. The whole siphon wall outside and inside is covered by a jelly-like tissue, containing nuclei, and at places showing elongated cell-walls, *c*.

THE DIGESTIVE TRACT.

The mouth.—The mouth is situated in the median line between the two labial palps, and just behind the anterior adductor muscle when it is present. It is not sharply marked off from the œsophagus, being a funnel-shaped opening for it.

The palps.—These are two lips or folds anterior and posterior to the mouth. They extend backward on either side toward the anterior ends of the gills. They are often large and plate-like (*Nucula* and *Yoldia*). In other cases they may be prolonged as narrow bands (*Mytilus*) or they may be short and thick (*Ostrea*). The first case is shown in Fig. 52, Pl. LXXXVII, at *p*, where the palp extends from the mouth back to the gills (*g*) at the posterior end of the visceral mass. Here and in *Nucula* (Mitsukuri No. 13) the palps possess a long appendage (*ap*) supposed to aid in the collection of food. These may be protruded to the exterior just below the siphons.

Fig. 95, Pl. XCIII, shows the relation of the palps to the mouth, as well as their general shape. The figure represents the anterior end of the body of *Mytilus*, cut in a vertical transverse plane just posterior to the mouth. The most posterior, or inner palp (*ip*), extending on either side of the mouth opening, hides the latter, which is situated just above *mo*. The outer palp (*op*) occupies a similar position before the mouth. A dorso-ventral striation is seen to exist over the lower three-fourths of the inner surface of the palp (at *op*), and the surface of the inner palp, opposed to it, similarly thrown into folds or ridges.

These ridges have very much the same appearance to the unaided eye as the gill filaments, and have led many observers to mistake the palps for gills. They are simply ciliated ridges occurring on but one side of each palp—that next to the mouth.

Sections across these folds would differ somewhat in appearance according to the regions from which they were taken. Fig. 62, Pl. LXXXVII, represents a section across the folds of the palp of *Ostrea* in the ventral region, in this case farthest away from the attached basal portion (Fig. 97, Pl. XCIV, *ip*). The folds at this free edge of the palp are generally thicker than at the base, and are thrown into two or three small secondary folds (*sf*). The ciliated epithelium covering the folds is composed of much elongated cells, more greatly developed on the side of the fold on which occur the secondary folds. The bases of the folds rest upon a more or less complete connect

The crystalline style appears here and there in various groups. It may be present in one form and entirely absent in another closely related to it. In the primitive *Nuculidæ* it is represented by a mere rudiment (Pelseneer). It has been homologized with the radular sac of the *Glossophora*, but probably not correctly, on account of its point of origin. Its function also is unknown. It has been regarded as a store of reserve food material. Barrois (No. 1) and Pelseneer suppose that its purpose is to surround sharp particles in the digestive tract, which might injure its lining epithelium. Such a function seems to me improbable. It is generally supposed that food is taken into the mouth and stomach by ciliary action only. In many forms large quantities of sand are taken in by the same means. It would be impossible for the style substance to protect the stomach walls from such a mass of foreign bodies by covering them. Only when an extraordinarily large and sharp piece enters, could this function of protecting the stomach take place, which seems altogether improbable. The lining cilia of mouth and œsophagus could probably not pass into the stomach a foreign body much larger than a grain of sand. The digestive tracts of those forms which have no style are probably not easily injured.

THE LIVER.

This gland is paired, there being one-half on each side of the visceral mass. In cutting into the visceral mass, however, the dark-brown gland surrounding the stomach gives no appearance of being of two parts. If the stomach be injected, it will be found that the injecting substance has penetrated the liver mass through its ducts, which open into the stomach. The ducts are, in the main, very fine and traverse the liver in every direction.

The openings of the ducts into the stomach are usually large and cause much irregularity in its walls (Fig. 2, Pl. LXXIX, *s*). The position of this mass and its extent in *Ostrea* are shown in the figure to which reference has just been made (*l*). It extends in this region of the stomach from near the mouth dorsally, to the extreme ventral wall of the visceral mass. It nowhere touches the walls of the visceral mass excepting below, being surrounded by the sexual gland (*g*). Its extent in *Venus* is readily seen by referring to Figs. 11, 12, and 13, *l*, vertical sections approximately through the anterior, middle, and posterior parts of the stomach. In this case, in the oyster, in *Cardita* (Fig. 51, *l*), and in *Mytilus* (Figs. 33 and 34), the genital gland (*g*) more or less completely surrounds the liver. In *Pecten* (Fig. 44, *l*) the liver in the region of the stomach is only bounded by the sexual gland on its ventral surface. This is also the case in *Mya*, shown in Fig. 25, *l*. The posterior end of the stomach in this form (Fig. 26) is not surrounded by the liver, but by the sexual gland. Though varying a great deal in size in different lamellibranchs, the liver seldom, if ever, extends farther backward than the posterior end of the stomach. It extends forward, however, to the anterior end of the visceral mass, as is shown in the sections anterior to the stomach. The posterior end of the liver is irregular, and in vertical sections of this region portions of the sexual gland may be seen surrounded by the liver mass (Fig. 34, *g*). The boundaries of both glands are irregular and they everywhere lie closely applied to one another.

As a general thing, the secreting tubules of the liver are packed together very closely. In the more primitive forms, however, as *Nucula*, *Yoldia*, and *Solenomya*, the

liver mass is not at all compact. In *Yoldia* the liver tubules, surrounded by the sexual gland, are free from one another throughout most of the extent of the gland, being only connected by long branching threads of a connective tissue.

THE GENERATIVE MASS.

The greater part of the visceral mass is made up of this organ and the liver. It is of a much lighter color than the latter gland and varies much in its outward appearance in different forms. It is a large gland, surrounding the liver, and constitutes the posterior part of the visceral mass. It grows in between bundles of muscle fibers of the foot, wherever spaces may be left. In *Ostrea* it reaches the body wall anteriorly, surrounds the liver, and closely invests the intestine throughout almost its entire extent. A part of the visceral mass extends down under the pericardium, and backward for some distance below the adductor, where it ends in a blunt, rounded point, forming most of the anterior boundary of the cloacal chamber. The intestine runs almost to this extreme tip and then returns toward the stomach. It is, in this region, under the adductor muscle, entirely surrounded by the sexual gland (Fig. 7, Pl. LXXX, *g*), which is also seen at the extreme posterior part of the body represented in Fig. 8, *g*. In the oyster, also, the visceral mass extends in much the same way above the pericardial cavity and over part of the adductor. It consists here of the rectal part of the intestine, surrounded by a layer of the generative gland, which becomes thinner and thinner until it finally disappears, and the extreme tip of the rectum is continued on into the cloaca without this covering. This is seen in section above the heart region at *g*, Figs. 4, 5, 6, and 7. In Fig. 6 it becomes thinner, and in Fig. 7 posterior to the pericardial chamber, and over the adductor it has almost disappeared. This backward extension surrounding the rectum is an unusual one. In *Venus* the generative gland penetrates into spaces between the uppermost muscle bundles of the foot, as is usual in forms with a locomotor foot. The posterior part of the visceral mass has many scattered muscle bundles, generally transverse, as indicated in Figs. 14 and 15, *mf*, running from one side to the other. The sexual gland pushes down among these muscles for a considerable distance. In a case like *Yoldia*, where the organs of the visceral mass are not at all crowded, the sexual gland still occupies a considerable part of the base of the foot. The definite boundaries of the gland in *Mya* will be seen by a glance at Figs. 24 to 26, Pl. LXXXIII, *g*.

In *Anomia*, greatly modified in many ways on account of its fixed condition, the sexual gland is very asymmetrical, extending out into the mantle on the right side. In *Mytilus* the foot (not present in *Anomia*) is entirely muscular and contains none of the sexual gland. Much of the visceral mass, also, is occupied by the large byssus muscles, and, as a result, the generative gland has pushed out into the mantle lobes of both sides and completely fills them, as seen in Figs. 32 to 41, *m*.

The ducts leading from the sexual glands open in a variety of ways. They may open directly to the exterior or into the excretory organs. If into the latter, they may open near its pericardial end, its middle, or its external end. It is probable, from the fact that in the most primitive forms this gland opens into the pericardial end of the kidney, that the free opening to the exterior is, in some cases, a secondary condition, as shown by Pelseneer (No. 17).

In a majority of cases the sexes are separate, but hermaphroditism exists in very many forms. Pelseneer points out the fact that it exists in isolated forms, species in certain genera, as in *Ostrea*, *Pecten*, and *Cardium*, and whole genera in certain families, as in the case of *Cyclus*, *Pisidium*, and *Entovalva*. He says: "Chez tous ces animaux la glande génitale *elle-même* est hermaphrodite; elle produit dans toute son étendue des œufs et des spermatozoïdes, ou bien si une partie est spécialisée pour donner naissance à chacun de ces produits, ceux-ci sont amenés au dehors par une seul canal, *hermaphrodite* (*Pecten*)."

The European oyster, *Ostrea edulis*, is hermaphrodite, but in the American form, *O. virginiana*, the sexes are separate. While rearing the young of this form from the eggs at Woods Holl, with Mr. Harrison of the Johns Hopkins University, we found a specimen apparently containing both eggs and spermatozoa. On sectioning parts of the generative gland, I found it to be hermaphrodite, as was suspected. The large follicles (Fig. 72, Pl. LXXXIX) were generally more or less united, and their lumens everywhere, in specimens taken from a number of different parts of the glands, appeared full of ripe spermatozoa. The ova, with their distinct nuclei, were apparently unripe, though many were free from the follicle walls. The majority of them were yet attached. The cells of the follicular epithelium showed ova in all stages of growth, and none of them, apparently, were giving rise to spermatozoa.

This specimen was obtained late in June, near the end of the breeding season. Whether or not its sexual glands indicate the change in function from male to female or from female to male, which possibility has been suggested for some lamellibranchs, I can not say; but, as abnormal hermaphroditism often occurs in all groups of animals, this may be an example of it.

The sexual gland of *Pecten irradians* is hermaphrodite, and there are an ovary and a testis on each side of the visceral mass. Both glands are ventral to the liver (Fig. 44, *g*) and have a spongy appearance. The testis is the more ventral of the two and is of a cream color. The ovary, situated above this, has a reddish hue, which is very marked in the living animal.

Fig. 71 represents a section passing vertically through the outer wall of the visceral mass, where the testis and ovary are closely apposed. The body wall is represented at *ep* and consists of a single layer of columnar, ciliated, epithelium cells, whose nuclei are about equally distant from their outer ends and the thick basement membrane (*bm*). In this epithelium are many conspicuous gland cells (*glc*). Between it and the follicles of the generative gland is a thick layer of connective tissue, extending in between the follicles. The follicles of the ovary (*ov*) are not so regular in outline when seen in section as those of the testis (*t*). The walls of the latter bear a follicular epithelium (*fep*). In the ovary, the cells of this layer are in all stages of development into eggs. The eggs themselves, crowding the follicles, possess a very thick egg membrane and their protoplasm is finely granular. A duct from the follicles is seen at *d*.

The mother cells of the spermatozoa (*fep*) are circular and of constant size in the follicles of the testis (*t*). As we follow the mass of cells inward from these mother cells they become very gradually smaller and smaller, until their final divisions result in the spermatozoa. These are so arranged that their "tails," in forming, project in extended masses toward the lumen of the follicle and give it a radiating appearance.

surround the entire adductor muscle and visceral mass. In *Ostrea*, each of the four gills is connected above with the ones next to it, and the outer ones are also connected with the mantle. A vertical section (Fig. 2, Pl. LXXIX) shows each gill to be made of two lamellæ (*ol* and *il*), leaving a space (*w*) between them. They are united to each other above, the top of the inner lamella of one to the top of the outer lamella of the next, and on the median line the opposed inner lamellæ. In Fig. 2, which is a section near the anterior end of the gills, they are also all united above to the visceral mass. A little farther back, however (Fig. 4), the two inner lamellæ of the inner gills only are attached to the body above. Farther back still, under the adductor (Fig. 8), the gills are entirely free from the parts above. In all regions, however, the outer lamellæ of the outer gills are united with the mantle, as may be seen in all the figures of cross-sections of this form.

By this concrescence of the gills above, the mantle chamber below is completely shut off from all the spaces which appear in section above them. Posteriorly these epibranchial chambers open into one another in one large cavity (Fig. 8, *c*), forming a cloacal chamber. Its position on the posterior side of the adductor muscle is shown at *c* (Fig. 97, Pl. XCIV).

The gill lamellæ are made of innumerable parallel filaments united to each other in various ways in different forms, and always leaving openings through which water may enter the epibranchial from the branchial chamber. This current is caused by the ciliated cells of the filaments. The spaces between the lamellæ are called water tubes. The currents from the epibranchial chambers pass posteriorly to the cloaca. Into it, from above, opens the rectum in all cases (Fig. 97, *r*). In those forms which possess siphons, the cloaca opens into the anal siphon (Figs. 93 and 94).

The more common position of the gills differs from that of the oyster, in that a foot is generally present, situated on the ventral side of the visceral mass and protruding between the inner gills. If this should occur in *Ostrea* and the gills should then be moved up on the sides of the body, we would have the condition in *Venus* represented in Fig. 14. The whole foot and visceral mass here separate the chambers of the right and left sides, instead of their being side by side, as in the former case. Behind the visceral mass and foot, the inner gills join one another, forming a branchial septum, which is continued posteriorly to the base of the siphons, and still preserves a complete separation between the cloaca and branchial chamber (Fig. 93, Pl. XCIII).

Here also, as in *Mya* and many other forms, the epibranchial chamber is divided anteriorly into four parts, two on each side of the body, farther back into two, and finally these unite into one, the cloaca.

In *Mytilus* there are no sharply defined epibranchial chambers, for, as may be seen in Figs. 32 to 41, the inner lamellæ of the gills do not fasten to the body wall, nor do the outer lamellæ unite with the mantle as they do in the forms just noticed. It thus happens that the water tubes (*w*) open directly into the branchial chamber, whence their supply is obtained. The backward current is, however, confined to the dorsal part of the branchial chamber and leaves it by a special siphonal opening at its posterior extremity. (Fig. 87, Pl. XCIII, *co*, a view of the mantle edge in the posterior region.)

Filamentous gills of this sort, often, however, undergoing great complications, are possessed by the great majority of lamellibranchs. The gills of a few primitive forms (*Nucula*, *Yoldia*, *Solenomya*), however, are entirely different in appearance. They were

first made known by Mitsukuri (No. 13). Instead of filaments, each gill is made up of a number of flat plates, placed one against another, the two gills on each side being supported by a common muscular membrane, which is attached in the usual position to the sides of the visceral mass. The palps in *Nucula* and *Yoldia* are very large and extend back for some distance upon the visceral mass. The gills, posterior to them, extend backward to the posterior end of the body. Fig. 92 represents half of two gills of *Yoldia*. The cut surface at the right of the figure exposes not one continuous plate, but two plates, one on each side of the supporting membrane *m*. On the ventral side of the gill, opposite the supporting membrane, is a groove, not well shown in the figure (*gr*), separating the plates of either side. Other evidence will be given to show that these plates are really separate, and one plate does not extend entirely across the gill.

This organ in *Solenomya* is very similar to the one described. Here (Fig. 91) the gill on either side is attached to the visceral mass by a short supporting membrane in such a way as to almost completely envelop the posterior part of the body. The outer plates of the gill now extend upward on the side of the body instead of hanging down below the point of the attachment of the supporting membrane, as in *Yoldia*. The plates of the upper row differ in shape from those of the lower, being longer and narrower.

There is yet another condition of the respiratory organs of lamellibranchs, first described by Prof. Dall, of the Smithsonian Institution (No. 4). In *Cuspidaria* and *Poromya*, probably very far removed from primitive forms, the gill as such seems to have disappeared. On either side of the body, extending from the walls of the visceral mass out to the mouth, is a thick, horizontal, muscular membrane. It extends the entire length of the animal, from close behind the anterior adductor back to the siphonal septum, and separates the mantle chamber on either side of the body into an upper and a lower chamber. Through this membrane open a number of orifices of various arrangement, which allow a passage of water upward from the lower into the upper chamber. This latter corresponds to the usual epibranchial chamber, water obtained from the chamber below being discharged through the anal siphon. The upper chamber is stated by Dall (No. 5) to be used as a marsupium.

There seems to be a question as to whether or not the gill has disappeared in those forms and whether the muscular membrane is homologous with the gills or a morphologically different organ. Dall (No. 4) some years ago expressed the view that this membrane was not morphologically a gill, but that it was a great extension anteriorly of the muscular siphonal septum found greatly developed in other forms. A gradual transition, in which the true gills become smaller while the siphonal septum increases in area and extent, is traced through the forms *Lyonsia*, *Lyonsiella*, and *Verticordia*, all these forms possessing true gills. With the loss of the gills the septum takes upon itself their function of respiration, and the progress of its specialization for this purpose after the gills have disappeared is illustrated in the series of forms *Myonera*, *Cuspidaria*, *Ctenoconcha*, and *Poromya*. There are possibly cases in which the muscular septum is made up of structures diverse in their origin, the anterior part being from the gills and the posterior from the siphonal septum.

More recently Pelseneer homologized this septum with the gills (No. 17). The reasons given for this view are that, while it is connected with the siphonal septum,

I have not been able to determine how many times a mother cell divides in forming spermatozoa, for the cells are all rounded and give no evidence of their divisions, as they do in the testes of many animals. A duct of the testis containing spermatozoa is shown at *d*. The ducts of both testis and ovary are composed of slightly columnar, ciliated cells. In the wall of the duct of the testis is shown a single deeply stained cell, which is evidently a gland cell.

In the mother sperm cells of *Mytilus* the chromatin is arranged in a crescent-shaped mass at one side of the nucleus.

The spermatozoa vary greatly in different forms, both in size and general shape. In a single follicle of the gland of any individual, also, they are of various shapes, often very markedly different from the normal.

Fig. 67, Pl. LXXXVIII, represents a very few spermatozoa illustrating these points. The "tails" in all these cases are more than twice the length represented in the figure. The sharply pointed spermatozoan "head" of *Yoldia* is shown (*a*) to be similar to that of *Venus*, (*b*) in that both are elongated and conical in outline. The latter, however, are always bent. In a very large number of cases the tail proceeds from the narrower end of the head (*c*). The spermatozoön of *Pecten* is represented at *d*. It is actually much shorter than that of *Venus*. They frequently show a form similar to *f*. The spermatozoön of the oyster (*e*) has a nearly spherical head, which gradually tapers off into the tail. If spermatozoa are characteristic even of species, as has been suggested, it may be of interest that those of *Anomia* are very similar to those of the oyster, since Pelseneer does not regard these forms as being in any way closely related.

THE VASCULAR SYSTEM.

The heart, the chief organ of the circulatory system, is in the majority of cases situated on the dorsal part of the body and is greatly elongated from before backward. It consists of a muscular ventricle and two lateral, generally more delicate, auricles opening into it, one on either side. The organ lies in an extensive pericardium. The usual relations in position between these parts may be seen in Fig. 45, Pl. LXXXVI, where *ven* represents the ventricle, *au* the auricle, and *p* the pericardium. In a few cases, as in the oyster, the heart has changed from its usual position, and its long axis is dorso-ventral. In Fig. 97, Pl. XCIV, the organ may be seen represented as lying beneath the pericardium, just in front of the adductor muscle. The ventricle is most dorsal, and the two auricles open into it ventrally; these are pigmented; they receive blood from the gills.

As a rule the ventricle of the heart is traversed by the rectum, but this does not occur in *Nucula*, *Arca*, *Anomia*, *Meleagrina*, *Ostrea*, or *Teredo*. Its position in the ventricle of *Pecten* is shown in Fig. 45, *r*. In *Solenomya* the rectum is close to the ventral wall of the ventricle, instead of being connected with the dorsal wall, as is generally the case. (Pelseneer, No. 17.) In the forms in which the ventricle is not traversed by the rectum, *Nucula*, *Arca*, and perhaps *Anomia* are primitive forms, while *Ostrea* and *Teredo* are among the most specialized of lamellibranchs. But in *Nucula*, *Arca*, and *Anomia* the ventricle is dorsal to the rectum, while in *Meleagrina*, *Ostrea*, and *Teredo* it is ventral to it. In certain primitive mollusks (*Cephalopoda* and *Amphineura*), the ventricle of the heart is dorsal to the rectum, as in *Nucula*, etc., and it is probable that this is the primitive condition.

another, and the same number on the other side, opposite these, may contract themselves apparently from every direction, thus giving the appearance of a deep groove running entirely around the gill. Now this contracted zone begins to move along the length of the gill and it may move in either direction. In this wave of contraction but three or four plates on either side are ever concerned at one time. These waves are often single, and at times several may follow one another in succession.

Still another wave contraction may often be noticed on the ventral sides of the plates. The ventral side of a single plate, or at most two plates, is affected at one time. These waves occur independently on either side of the gill. A single plate bends a certain region of its ventral surface forward or backward, so as to separate this region from one of the neighboring plates and bring it close to the plate on the other side, either before or behind it, as the case may be. This latter plate quickly bends in the same way, the first one assuming its original position and then the succeeding plates, thus causing a wave of this bending to run along the length of the gill. These waves may run either forward or backward. Single plates may contract slightly independently.

If a gill be dissected out from the body, these contractions still continue to take place whenever it is touched. The action of the cilia is so powerful that the entire gill is made to move about in the water.

Collection of food.—Mitsukuri came to the conclusion that this primitive form of gill was concerned only in the aëration of the blood, and that it was probably not concerned in the procuring of food. I was able to observe in the case of *Yoldia*, however, that not only was the function of gathering food possessed by the gills, but that it was performed with amazing rapidity. Carmine particles in the water once coming in contact with the ventral edges of the plates, having been swept there by the powerful currents which these ciliated borders set up, are at once hurried along toward the wide, median, ventral groove of the gill, into which they are thrown. On the way to this groove they have evidently become covered by mucus secreted by gland cells; for the separate particles of carmine are soon firmly cemented together, and passing along the groove anteriorly, less rapidly than on the edges of the plates, though still at a comparatively fast rate, they are finally piled up at its anterior end and gradually passed upon the surface of the palp.

Structure.—A diagrammatic view of the ventral side of the gill is given in Fig. 78, Pl. XCI, in which the thickened ventral edges of the plates (*p*) are shown on either side of the groove (*gr*). These edges in the living gill are only slightly bent downward, and are not so curved in outline as represented in Fig. 81, which was drawn from a hardened specimen. From the groove (*gr*, Fig. 78) to the point *cj*, the plates are in no way connected with one another, and one may see entirely through the gill between them, when examining from below.

At the point *cj*, where the edge of the plate turns abruptly upward, occurs a ciliated junction not before described in these forms, between adjoining plates. The cilia from neighboring plates interlock closely, making a comparatively substantial union. This ciliated junction is not confined to the point mentioned, but extends from it upward on the lateral sides of the gill for about two-thirds of the distance to the upper pointed extremities of the plates, the ciliated union being confined to the lateral edges of the plates.

runs forward to the visceral mass and mantle. The latter takes its origin slightly posteriorly to the first, very close to the extreme anterior end of the ventricle, and runs directly backward beneath the rectum and in the upper wall of the pericardial chamber. Upon reaching the adductor muscle it turns downward, running along its anterior surface to a little below its middle, and then penetrates its tissue and becomes distributed among the fibers.

The oyster probably came, in its degeneration, through a form with an anterior and posterior aorta. But in this case the posterior aorta must have shifted its position from the posterior end of the ventricle to its anterior dorsal end.

Arteries break up, not into capillaries, but into irregular blood spaces, in all tissues of the body which they penetrate. In the gill filaments, however, the blood channels are of more regular size, and in many cases (*Pecten*, Fig. 83) are easily seen to be lined with a distinct endothelium. In the walls of the digestive tract and in the labial palpi also, the blood spaces are quite regular, and much like definite vessels. These are lined by an endothelium, as is shown in Fig. 75, Pl. XC, *bv*, a section of the mouth fringe of *Pecten irradians*.

The blood of lamellibranchs is colorless, with a few exceptions, and contains many corpuscles. Some of the *Arcas* and *Solen* (Lankester, No. 8) have corpuscles containing hæmoglobin, so that the blood is distinctly red.

The relative amount of the blood is very great in some locomotor forms where it is used in protruding the foot, and in such sedentary forms as *Ostrea* and *Mytilus* is comparatively small.

The course of the circulation is as follows: From the ventricle of the heart the anterior aorta conveys the blood forward along the dorsal wall of the visceral mass, over the stomach, and then down into the foot. From this main artery many branches are given off to the tissues of the liver, sexual glands, palps, digestive tract, and foot. Where the posterior aorta is present it is in most cases distributed mainly to the mantle folds, and also supplies the siphons of the mantle and the posterior adductor. If the posterior aorta be absent, these posterior tissues are supplied by a branch from the anterior aorta. From the irregular sinuses into which the arteries empty, the blood is collected in larger vessels and conveyed to a vessel beneath the pericardium, called the sinus venosus. Thence it passes to the gills, traversing on the way the walls of the nephridia, where waste products are excreted. The circulation is completed by the return of the blood from the gills to the auricles of the heart.

The path of the blood through the gill filaments is not well known and would be impossible to determine in those forms in which the gills have become greatly specialized, owing to their complex form. On account of the colorless condition of the blood corpuscles also, their movement in the filaments can not be followed.

It seems altogether probable that the manner of the circulation in the gills is very dissimilar in different groups of lamellibranchs. In those forms in which the gills are made up of a series of leaf-like plates (*Nucula*, *Yoldia*, *Solenomya*), each of these is little more than a blood sinus (*Yoldia*, Figs. 79, 80, 82; *Nucula*), around whose outer edge a blood channel is more distinctly marked out. While a circulation may be more or less distinct here, it can not be perfectly so.

In forms with a descending and ascending portion in the filament, and where the latter is not in concrescence at its extremity with the mantle or neighboring filaments, the blood must flow out to the extremity of a filament and then back again, perhaps,

size throughout, and through them is evenly distributed a light yellow pigment, which is quite abundant and probably gives the red tint to the living gill. Immediately above the ventral edge, these sides expand laterally, leaving a large space (*s*), in which are numerous blood corpuscles. At the dorsal edge of the plate (*d*) there is also a marked widening of the bounding walls. The walls in the center of the plate are found in sections to be greatly convoluted (*f*), probably due to the contraction of muscular fibers (*mf*) contained within the space between the walls, to be described later.

In these three regions described, the walls are connected with one another by numerous, branching, lacunar cells (*lac*), though they are less numerous in the central region (*f*).

The entire interior of the plate is seen to be of one continuous blood space, with definitely constricted areas and enlarged channels. While blood corpuscles are naturally more abundant in these channels, they are found in all parts of the interior of the gill plate.

Fig. 82 represents a section cut horizontally through the gill plates of one side in a plane indicated by the line *b* in Fig. 81. In this region, above the thickened ventral border, no chitinous framework appears. The outer edge of each plate is rounded and composed of short columnar cells, bearing very short, fine cilia on the extreme outer or frontal surface (*e*); but on the lateral sides of the rounded edges are narrow lines of cilia interlocking closely with each other (*cj*). At times, spaces (*s*) are found where the ciliation is absent, though these may perhaps be due to a mechanical tearing of one plate from another. The extent of these ciliated lines on the sides of the plates has been referred to above. The remaining parts of the plate walls are the same as already described, though less convoluted. In this section a part of the supporting membrane of the gill has been cut across. Its surface epithelium (*ep*) is columnar, and many of the cells bear thick spines, perhaps bundles of cilia. The inner part of the membrane is made up chiefly of muscle bundles (*m*).

Fig. 80 represents another horizontal section, passing close to the dorsal end of the plate (in the plane of *c*, Fig 81). Here the ciliated connecting lines or rows have disappeared and the epithelium is everywhere the same pigmented, indistinct kind above described for the main body of the plate. In this dorsal region, the lacunar cells (*lac*) are very numerous, and their processes, extending from one wall to another, are generally fine and thread-like.

That the plates of one side of the gill structure are not continuous with those of the opposite side is evident from a section passing horizontally in the plane indicated by *d* in Fig. 81. Such a section is represented by Fig. 48, Pl. LXXXVI. When the plates come together from either side on the median line (*ml*) they are not opposite each other, but on the contrary, break spaces. They are figured by Mitsukuri as being opposite each other in *Nucula*. The space *a* represents the interior of a plate, and *b* the space between two plates. The wall of one plate, then, runs over on the median line of the gills and becomes continuous with the wall of the next on the same side.

Fibers have been described in this gill by Mitsukuri as running down into the plates from the supporting membrane above. He regarded them as chitinous structures, serving to keep the plate expanded for purposes of aëration. They are shown in Fig. 79 and Fig. 48, *mf*, as being cut across more or less transversely. They are always closely applied to the inner face of one of the walls of the plate, but whether always to the anterior or posterior surface I do not know. A longitudinal, nearly vertical,

are connected with the ventral floor of the pericardium on either side anteriorly, and this opening on one side is shown in Fig. 45, *n*, the adductor muscle here having been entirely cut away.

The position of the organ in *Ostrea* is seen in Fig. 97, Pl. XCIV, at *n*. Its anterior end lies under the pericardium, and it extends backward, close under the adductor, as far as the small notch between the light and dark muscle fibers. It is thus seen, as in *Pecten*, to expose a great part of its wall directly to the water in the epibranchial chamber. The glands of either side are entirely separate from one another. The secreting portion of the gland gives off a great number of branching diverticula, lined by an excretory epithelium.

A portion of one of these diverticula is represented in Fig. 54, Pl. LXXXVII. The lining cells (*exc*) are columnar and rest upon a thick basement membrane. The cell protoplasm is mostly collected at the bases of the cells. The distal ends contain large, watery vacuoles which are finally discharged into the lumen of the tube (*l*). Many of these vacuoles contain a small, round particle which stains deeply and which may be of a concretionary nature. Concretions as commonly found in other forms, however, seem to be entirely wanting here. The products discharged into the lumen are undoubtedly liquid, for by tapping on the cover, when fresh preparations are used, they may easily be made to run into one another and form larger masses. None of these cells give evidence of ciliation.

Figs. 56 and 57 represent concretions from the secretory cells of the kidney of *Pecten*. They are sometimes very large and their concentric structure is easily seen. Figs. 58 and 59 are from macerated preparations. The former shows a basal nucleus (*n*) and the concretion in the distal portion of the cell (*con*). The concretions possess a more dense, deeply staining, central portion of varying shapes and sizes. Scattered through the cell substance are many small, vacuole-like bodies (*vac*), probably the first appearance of the excreted products in fluid form, which afterward construct the solid concretion. Other cells (Fig. 59), of a more elongated shape, appear to contain only watery vacuoles (*vac*).

The secretory cells are deeply pigmented in most lamellibranchs, but are entirely devoid of coloring matter in the oyster. The gland is thus rendered very inconspicuous and was for a long time overlooked. It has been described in the European oyster (*Ostrea edulis*) by Hoek (Journ. Soc. Néerlandaise de Zóol., 1883).

By means of this tube-like nephridium, the pericardial cavity is connected with the exterior, and it has often been supposed that water entered the pericardium by this means. This has, however, never been demonstrated, and there are reasons for supposing that it does not occur. Among these are the facts that the narrow channels leading from the pericardium and to the exterior possess, as a rule, many cells with very great cilia, which have been shown, in some cases, to cause a current outward; and also in *Pecten* there are valves guarding the opening into the pericardium, preventing any such back flow into it.

Garner has shown that the sexual gland of *Pecten* opened into the kidney. In examining the nephridia of this form in the spring and early summer, I have almost always found that they contained eggs in various stages of development, often in very great numbers. They are, in all probability, the eggs of the individual examined, which have lodged in the kidney instead of being thrown out to the exterior, and not eggs from some other mollusk taken with the surrounding water. In this

case they have probably become fertilized from spermatozoa taken into the kidney from the exterior, having come from another individual, if it is always true that the male elements in these hermaphrodite forms are always ripe before the female, as observations seem to indicate. The great majority of eggs are of course discharged into the water, and there become fertilized and develop.

It thus happens that the spacious kidney of *Pecten* becomes a brood pouch for some of the young, and I have seen a kidney containing great numbers of eggs far advanced in segmentation, which, it seems probable, both on account of their number and the connection between kidney and sexual glands, developed there from the beginning. It is true that this arrangement may be a purely accidental one, but I am inclined to believe that the advantage gained in protecting so many embryos for so long a period in their development is considerable, and that on this account the kidney may, by the operation of natural selection, have become especially adapted for this function.

THE NERVOUS SYSTEM.

Of the three pairs of ganglia the cerebral are usually situated near either side of the mouth and are joined by a supraœsophageal commissure. They are generally close to one another in the more primitive forms. The visceral ganglia, generally placed in the ventral side of the posterior adductor, occupy in *Solenomya*, *Nucula*, and a few others, a position in front of it. Connected with the pedal ganglia is the otocyst. Though it often lies on the surface of the latter, it is probably always innervated from the cerebral ganglia. In some cases the otocyst contains a single otolith, in others there may be several small particles.

Sections of the otocyst of *Yoldia* show an epithelium, the cell walls of which could not be distinguished. Nuclei of different shapes and sizes are scattered about irregularly through it. These cells rest upon a dense supporting membrane, and the whole is enveloped in a capsule possessing a fibrous appearance. There is but a single large otolith, whose concentric structure is very evident. There is also in the cavity of the otocyst what appears to be a coagulated fluid. The lining epithelium, as far as I was able to see, possessed no trace of cilia. This apparent absence of cilia has also been described for the otocyst of *Nucula*, by Pelseneer (No. 17).

THE GILLS.

The gills, of which there are four, hang in the branchial chamber. They are represented in Fig. 96, Pl. XCIV (*Venus mercenaria*), the right valve and mantle lobe having been dissected off. The line of attachment of this mantle lobe dorsally, beginning at the posterior end at the side of the siphons, is upward along the back of the posterior adductor; thence it proceeds forward in a curved line near the top of the pericardium and visceral mass to the anterior foot-retractor, which pierces it, and over the anterior adductor.

The free edge of the left mantle lobe is seen at the point *me*. An extremely large branchial chamber is thus formed, the upper boundary of which is the line of attachment between the mantle and outer gill. In it, over the walls of the visceral mass, hang the gill plates (*og* and *ig*), and below is suspended the foot. The gills of *Ostrea virginiana* (Fig. 97) extend from near the anterior end of the body backward, and up for some distance on the posterior side. In *Pecten* their extent is so great as almost to

surround the entire adductor muscle and visceral mass. In *Ostrea*, each of the four gills is connected above with the ones next to it, and the outer ones are also connected with the mantle. A vertical section (Fig. 2, Pl. LXXIX) shows each gill to be made of two lamellæ (*ol* and *il*), leaving a space (*w*) between them. They are united to each other above, the top of the inner lamella of one to the top of the outer lamella of the next, and on the median line the opposed inner lamellæ. In Fig. 2, which is a section near the anterior end of the gills, they are also all united above to the visceral mass. A little farther back, however (Fig. 4), the two inner lamellæ of the inner gills only are attached to the body above. Farther back still, under the adductor (Fig. 8), the gills are entirely free from the parts above. In all regions, however, the outer lamellæ of the outer gills are united with the mantle, as may be seen in all the figures of cross-sections of this form.

By this concrescence of the gills above, the mantle chamber below is completely shut off from all the spaces which appear in section above them. Posteriorly these epibranchial chambers open into one another in one large cavity (Fig. 8, *c*), forming a cloacal chamber. Its position on the posterior side of the adductor muscle is shown at *c* (Fig. 97, Pl. XCIV).

The gill lamellæ are made of innumerable parallel filaments united to each other in various ways in different forms, and always leaving openings through which water may enter the epibranchial from the branchial chamber. This current is caused by the ciliated cells of the filaments. The spaces between the lamellæ are called water tubes. The currents from the epibranchial chambers pass posteriorly to the cloaca. Into it, from above, opens the rectum in all cases (Fig. 97, *r*). In those forms which possess siphons, the cloaca opens into the anal siphon (Figs. 93 and 94).

The more common position of the gills differs from that of the oyster, in that a foot is generally present, situated on the ventral side of the visceral mass and protruding between the inner gills. If this should occur in *Ostrea* and the gills should then be moved up on the sides of the body, we would have the condition in *Venus* represented in Fig. 14. The whole foot and visceral mass here separate the chambers of the right and left sides, instead of their being side by side, as in the former case. Behind the visceral mass and foot, the inner gills join one another, forming a branchial septum, which is continued posteriorly to the base of the siphons, and still preserves a complete separation between the cloaca and branchial chamber (Fig. 93, Pl. XCIII).

Here also, as in *Mya* and many other forms, the epibranchial chamber is divided anteriorly into four parts, two on each side of the body, farther back into two, and finally these unite into one, the cloaca.

In *Mytilus* there are no sharply defined epibranchial chambers, for, as may be seen in Figs. 32 to 41, the inner lamellæ of the gills do not fasten to the body wall, nor do the outer lamellæ unite with the mantle as they do in the forms just noticed. It thus happens that the water tubes (*w*) open directly into the branchial chamber, whence their supply is obtained. The backward current is, however, confined to the dorsal part of the branchial chamber and leaves it by a special siphonal opening at its posterior extremity. (Fig. 87, Pl. XCIII, *co*, a view of the mantle edge in the posterior region.)

Filamentous gills of this sort, often, however, undergoing great complications, are possessed by the great majority of lamellibranchs. The gills of a few primitive forms (*Nucula*, *Yoldia*, *Solenomya*), however, are entirely different in appearance. They were

first made known by Mitsukuri (No. 13). Instead of filaments, each gill is made up of a number of flat plates, placed one against another, the two gills on each side being supported by a common muscular membrane, which is attached in the usual position to the sides of the visceral mass. The palps in *Nucula* and *Yoldia* are very large and extend back for some distance upon the visceral mass. The gills, posterior to them, extend backward to the posterior end of the body. Fig. 92 represents half of two gills of *Yoldia*. The cut surface at the right of the figure exposes not one continuous plate, but two plates, one on each side of the supporting membrane *m*. On the ventral side of the gill, opposite the supporting membrane, is a groove, not well shown in the figure (*gr*), separating the plates of either side. Other evidence will be given to show that these plates are really separate, and one plate does not extend entirely across the gill.

This organ in *Solenomya* is very similar to the one described. Here (Fig. 91) the gill on either side is attached to the visceral mass by a short supporting membrane in such a way as to almost completely envelop the posterior part of the body. The outer plates of the gill now extend upward on the side of the body instead of hanging down below the point of the attachment of the supporting membrane, as in *Yoldia*. The plates of the upper row differ in shape from those of the lower, being longer and narrower.

There is yet another condition of the respiratory organs of lamellibranchs, first described by Prof. Dall, of the Smithsonian Institution (No. 4). In *Cuspidaria* and *Poromya*, probably very far removed from primitive forms, the gill as such seems to have disappeared. On either side of the body, extending from the walls of the visceral mass out to the mouth, is a thick, horizontal, muscular membrane. It extends the entire length of the animal, from close behind the anterior adductor back to the siphonal septum, and separates the mantle chamber on either side of the body into an upper and a lower chamber. Through this membrane open a number of orifices of various arrangement, which allow a passage of water upward from the lower into the upper chamber. This latter corresponds to the usual epibranchial chamber, water obtained from the chamber below being discharged through the anal siphon. The upper chamber is stated by Dall (No. 5) to be used as a marsupium.

There seems to be a question as to whether or not the gill has disappeared in those forms and whether the muscular membrane is homologous with the gills or a morphologically different organ. Dall (No. 4) some years ago expressed the view that this membrane was not morphologically a gill, but that it was a great extension anteriorly of the muscular siphonal septum found greatly developed in other forms. A gradual transition, in which the true gills become smaller while the siphonal septum increases in area and extent, is traced through the forms *Lyonsia*, *Lyonsiella*, and *Verticordia*, all these forms possessing true gills. With the loss of the gills the septum takes upon itself their function of respiration, and the progress of its specialization for this purpose after the gills have disappeared is illustrated in the series of forms *Myonera*, *Cuspidaria*, *Ctenoconcha*, and *Poromya*. There are possibly cases in which the muscular septum is made up of structures diverse in their origin, the anterior part being from the gills and the posterior from the siphonal septum.

More recently Pelseneer homologized this septum with the gills (No. 17). The reasons given for this view are that, while it is connected with the siphonal septum,

the latter has a different innervation, while the muscular septum proper is innervated by the branchial nerve, and that it is in direct communication with the efferent lacunæ of the auricles.

DETAILED STRUCTURE OF THE GILLS.

The gills, so extremely varied in structure, are of very great importance on account of the relationship which they show to exist among various forms of the group, and have been thoroughly studied in a great many genera. The work of Posner (No. 19), Peck (No. 16), and Mitsukuri (No. 13), extended over a great field, and, together with the embryological observations of Lovén (No. 11) and Leydig (No. 10), has established a fairly satisfactory view of the phylogenetic history of the gill. Mitsukuri, who first made known the structure and nature of the gills of *Nucula* and *Yoldia*, now considered to be the most primitive of living lamellibranchs, was the last of these authors mentioned to publish his views; and he reviewed the work then completed giving a theory of the phylogenetic development of the gills, which is generally accepted as the true one. He says: "To review the whole matter, the lamellibranch gill wa perhaps originally a simple ridge on the side of the body, but, to increase the surfac of contact with the water, folds may have arisen on two sides of this ridge. If suc was the case, *Nucula* and *Yoldia* are still in a stage very little advanced from thi primitive condition. In course of time, however, as some of the Lamellibranchiat either owing to degeneration or some other cause, became incapable of extensive loc motion, these gills or folds were perhaps prolonged to form tentacular filaments, whic going on in their development, finally produced such complex gill structure as we s in *Mytilus*, *Unio*, *Ostrea*, and other forms, taking on at the same time functions total foreign to their original one."

THE GILL OF YOLDIA.

The primitive plate gills of these two forms, already briefly described, were fi studied by Mitsukuri, whose attention was directed chiefly to the former. On acco of poor material, he was not able to examine into the histology of the gill of *Yoldia* any detail, though he gave an account of the more important features of its struct

As described by Mitsukuri, the plates of the gill are suspended from above b thick membrane (Fig. 92). Close to its attachment to the gill plates, there is a bl channel running the length of the gill, and a similar vessel is present also in median line, just above the groove on the ventral side of the gill, which separates plates of either side from below. The course of the blood in these channels is known with certainty. Mitsukuri made very little out of the histology of the pl

Contractions.—If a living *Yoldia* be removed from the shell and examined i water, the gills will be seen to possess a deep-red color. The thickened ventral e of the plates seen from below are light red, but the thinner lateral edges are of a darker hue. The gills will be observed to be able to contract themselves in a va of ways and to be very susceptible to stimulation from without. In the first they may shorten themselves to a considerable extent from before backward, and all the movements of the form, this may be done very quickly. A contraction ma take place in such a way as to greatly reduce the circumference from side to sid from above downward. This last contraction is a very common one and at occurs in a curious way. At any point in the gill, three or four plates adjoini

another, and the same number on the other side, opposite these, may contract themselves apparently from every direction, thus giving the appearance of a deep groove running entirely around the gill. Now this contracted zone begins to move along the length of the gill and it may move in either direction. In this wave of contraction but three or four plates on either side are ever concerned at one time. These waves are often single, and at times several may follow one another in succession.

Still another wave contraction may often be noticed on the ventral sides of the plates. The ventral side of a single plate, or at most two plates, is affected at one time. These waves occur independently on either side of the gill. A single plate bends a certain region of its ventral surface forward or backward, so as to separate this region from one of the neighboring plates and bring it close to the plate on the other side, either before or behind it, as the case may be. This latter plate quickly bends in the same way, the first one assuming its original position and then the succeeding plates, thus causing a wave of this bending to run along the length of the gill. These waves may run either forward or backward. Single plates may contract slightly independently.

If a gill be dissected out from the body, these contractions still continue to take place whenever it is touched. The action of the cilia is so powerful that the entire gill is made to move about in the water.

Collection of food.—Mitsukuri came to the conclusion that this primitive form of gill was concerned only in the aëration of the blood, and that it was probably not concerned in the procuring of food. I was able to observe in the case of *Yoldia*, however, that not only was the function of gathering food possessed by the gills, but that it was performed with amazing rapidity. Carmine particles in the water once coming in contact with the ventral edges of the plates, having been swept there by the powerful currents which these ciliated borders set up, are at once hurried along toward the wide, median, ventral groove of the gill, into which they are thrown. On the way to this groove they have evidently become covered by mucus secreted by gland cells; for the separate particles of carmine are soon firmly cemented together, and passing along the groove anteriorly, less rapidly than on the edges of the plates, though still at a comparatively fast rate, they are finally piled up at its anterior end and gradually passed upon the surface of the palp.

Structure.—A diagrammatic view of the ventral side of the gill is given in Fig. 78, Pl. XCI, in which the thickened ventral edges of the plates (*p*) are shown on either side of the groove (*gr*). These edges in the living gill are only slightly bent downward, and are not so curved in outline as represented in Fig. 81, which was drawn from a hardened specimen. From the groove (*gr*, Fig. 78) to the point *cj*, the plates are in no way connected with one another, and one may see entirely through the gill between them, when examining from below.

At the point *cj*, where the edge of the plate turns abruptly upward, occurs a ciliated junction not before described in these forms, between adjoining plates. The cilia from neighboring plates interlock closely, making a comparatively substantial union. This ciliated junction is not confined to the point mentioned, but extends from it upward on the lateral sides of the gill for about two-thirds of the distance to the upper pointed extremities of the plates, the ciliated union being confined to the lateral edges of the plates.

An examination of sections made through the gill plates in different regions will give a better idea of these points. Fig. 79 represents a section cutting the plate of the gill of *Yoldia* in a plane represented by the line *a* in Fig. 81. This section thus shows the structure of both the ventral and the dorsal borders of the plate as well as that of its interior regions. The thick ventral border is shown at the upper end of the figure. As pointed out by Mitsukuri for *Nucula*, this corresponds in structure to that which is usual in the outer edges of the gill filaments of other lamellibranchs. This portion of the gill is supported by a framework of the so-called chitin (*ch*), which widens out at about the middle of its extent and makes the inclosed blood space a conspicuous channel at this place (*b*). The "chitin" is here quite thick and gradually becomes thinner in either direction.

The outer epithelium of the ventral edge is made up of closely packed columnar cells. Those at the extreme edge of the plate (*e*) bear peculiarly long and powerful cilia, which differ greatly in appearance from cilia in other regions of the ventral edge of the plate, or in fact in any other gill. In cross-section they are circular. The pencil cells, found frequently in other regions of the body in lamellibranchs, bear a stiff bristle which is found, by maceration, to be made up of several fused cilia. Whether or not these cilia may be of a similar structure I can not say, but it seems hardly necessary to suspect such a structure merely on account of their great size. Judging from their position and that of the other lines of cilia on the edges of the plate, these greatly developed cilia of the frontal cells are the ones which produce the rapid currents in the water over the ventral surface of the gill.

At some little distance inward from these frontal cells, the epithelium rises in a ridge on either side (*r*) and these bear a second row of cilia much shorter than the first, and very fine. They protrude laterally and outward, and their ends touch those of similar rows of cilia on contiguous plates. These rows, however, do not interlock with one another, and I believe that they serve simply to prevent currents of water bearing food particles and other foreign bodies, from getting in between the plates, and not at all as a means of connecting neighboring plates. I think, also, that similar lines of cilia on the filaments of other forms, which will be noticed, serve the same purpose.

A third line of cilia is borne by elongated cells, which do not, however, form a ridge, and is situated near the inner edge of the thickened, ventral edge of the plate. These cilia are longer than those of the second row and are also fine in appearance. In sections they appear bent outward toward the edge of the plate.

All these rows of ciliated cells are sharply defined and the cells between them bear no cilia. Gland cells usually exist in the frontal region of all lamellibranch gill filaments or plates. If they appear in this region in the gill of *Yoldia*, it is in very small numbers. I have frequently seen cells here which appeared much like gland cells, but have not been able to decide positively that they were such.

Lining the blood space inclosed by the chitinous layers is a perfectly distinct endothelium, represented in the figure. Not only were the slightly elongated nuclei easily seen, but also the cell protoplasm flattened out over the chitin. There was no possibility of confounding these cells with the nucleated blood corpuscles seen in the blood space, as certain observers have been accused of doing in other forms.

The thickened ventral edge, as seen in the section, is sharply separated from the remainder of the plate. This latter portion is made up of large epithelial cells, whose boundaries are not distinct and are seen but occasionally. These cells are of uni

size throughout, and through them is evenly distributed a light yellow pigment, which is quite abundant and probably gives the red tint to the living gill. Immediately above the ventral edge, these sides expand laterally, leaving a large space (*s*), in which are numerous blood corpuscles. At the dorsal edge of the plate (*d*) there is also a marked widening of the bounding walls. The walls in the center of the plate are found in sections to be greatly convoluted (*f*), probably due to the contraction of muscular fibers (*mf*) contained within the space between the walls, to be described later.

In these three regions described, the walls are connected with one another by numerous, branching, lacunar cells (*lac*), though they are less numerous in the central region (*f*).

The entire interior of the plate is seen to be of one continuous blood space, with definitely constricted areas and enlarged channels. While blood corpuscles are naturally more abundant in these channels, they are found in all parts of the interior of the gill plate.

Fig. 82 represents a section cut horizontally through the gill plates of one side in a plane indicated by the line *b* in Fig. 81. In this region, above the thickened ventral border, no chitinous framework appears. The outer edge of each plate is rounded and composed of short columnar cells, bearing very short, fine cilia on the extreme outer or frontal surface (*e*); but on the lateral sides of the rounded edges are narrow lines of cilia interlocking closely with each other (*cj*). At times, spaces (*s*) are found where the ciliation is absent, though these may perhaps be due to a mechanical tearing of one plate from another. The extent of these ciliated lines on the sides of the plates has been referred to above. The remaining parts of the plate walls are the same as already described, though less convoluted. In this section a part of the supporting membrane of the gill has been cut across. Its surface epithelium (*ep*) is columnar, and many of the cells bear thick spines, perhaps bundles of cilia. The inner part of the membrane is made up chiefly of muscle bundles (*m*).

Fig. 80 represents another horizontal section, passing close to the dorsal end of the plate (in the plane of *c*, Fig 81). Here the ciliated connecting lines or rows have disappeared and the epithelium is everywhere the same pigmented, indistinct kind above described for the main body of the plate. In this dorsal region, the lacunar cells (*lac*) are very numerous, and their processes, extending from one wall to another, are generally fine and thread-like.

That the plates of one side of the gill structure are not continuous with those of the opposite side is evident from a section passing horizontally in the plane indicated by *d* in Fig. 81. Such a section is represented by Fig. 48, Pl. LXXXVI. When the plates come together from either side on the median line (*ml*) they are not opposite each other, but on the contrary, break spaces. They are figured by Mitsukuri as being opposite each other in *Nucula*. The space *a* represents the interior of a plate, and *b* the space between two plates. The wall of one plate, then, runs over on the median line of the gills and becomes continuous with the wall of the next on the same side.

Fibers have been described in this gill by Mitsukuri as running down into the plates from the supporting membrane above. He regarded them as chitinous structures, serving to keep the plate expanded for purposes of aëration. They are shown in Fig. 79 and Fig. 48, *mf*, as being cut across more or less transversely. They are always closely applied to the inner face of one of the walls of the plate, but whether always to the anterior or posterior surface I do not know. A longitudinal, nearly vertical,

section, which passes through the supporting membrane, shows these fibers to be continuous with its musculature. I believe them to be muscles and the means employed to bring about the numerous contractions described above as taking place in the living gill. They do not penetrate the thickened ventral portion of the gill plates, nor do they seem to be present in their extreme dorsal portions; their insertion seems to be upon one wall of the plate and at all points throughout their length.

THE GILLS OF SOLENOMYA.

The external appearances of this gill have already been mentioned. The morphologically ventral surfaces (here lateral in position) are slightly enlarged, but not nearly so much so as in *Yoldia*. These specialized edges extend from the median ventral groove of the gill to the pointed outer ends of the plates.

The ventral edge of the plate is composed of entirely similar cells throughout, resting upon the usual chitinous layer (Fig. 77, *ve*). In the preparation from which the section represented was made, these cells had shrunk somewhat and separated from one another so as plainly to show their structure. They are columnar, have a finely granular protoplasm, the outer edge of which is deeply stained, and each cell bears several cilia. The cilia of all the cells are of the same length, excepting those on the extreme ventral border, where they are slightly shorter. At the lateral edges of the ventral border—never in the midline of the ventral surface—open certain gland cells (*gl c*), which are constantly and generally easily seen in a corresponding position throughout the gills of lamellibranchs.

Pelseneer (No. 17) figures two cells in the section of each plate (in the region just below the gland cells in Fig. 77), which are larger than the others and bear much longer cilia. These he probably means to compare with the "latero-frontal" cells of Peck, not so widely found among lamellibranchs, I believe, as seems to be so generally supposed. I am confident that these large cells do not exist in *Solenomya velum*. Pelseneer possibly mistook a gland cell in this region for a large nucleus and supposed it to indicate a large cell.

It is possible, though I think not probable, that the cilia on the sides of this ventral edge are used for joining the plates to one another, as described by Pelseneer. If such a junction exists it is a very slight one, for the plates, unlike those of *Yoldia*, are very easily separated. No direct interlocking of cilia is anywhere seen in sections as figured for *Yoldia* in Fig. 82. The ends of the cilia of neighboring plates merely touch each other (Fig. 77), and, as in other cases, I believe that they function principally in keeping food particles from entering between the plates, thus confining them to the ventral surface, where they may be rapidly swept to the median ventral groove of the gill and onward toward the mouth.

The chitin of the gill plate is thickest at some distance from the extreme ventral edge (*ch*), and it is here relatively thicker than in *Yoldia*. It extends, in a long, layer, entirely to the ventral edge, and also in the opposite direction, toward the ter of the plate. This latter extension rapidly thins out and disappears. No marked expansion of the blood space takes place between the chitin plates.

The epithelium of the walls of the plates is much like that of *Yoldia*, though cells are distinctly marked off from each other (*w*). They are more elongated their outer ends are rounded. These cells also contain a fine, equally distributed

ment in their protoplasm. Sections show no indication of the folding of the walls, such as is found in the gill of *Yoldia*, and I have seen no trace of the muscle fibers which I have described as being present in the interior of the plate in the latter form.

Endothelial cells are easily demonstrated, lining the interior of the chitinous layers (*ch*). Lacunar tissue, if it exists, was not made out, as the walls of the plate are everywhere closely applied to each other, in sections, and only here and there can very narrow spaces be seen between them.

THE GILLS OF ARCA PEXATA.

If an entire filament of the gill of this form be isolated, it will be seen to be made of a fully developed descending and ascending limb (Fig. 50, Pl. LXXXVI). The upper end of the ascending limb in the filaments of both gills is free from the mantle or side of the visceral mass, as in *Mytilus*. It bears an enlarged triangular end plate which turns outward. The anterior and posterior faces of this end are ciliated and form a large patch which closely interlocks with those in the same position on neighboring filaments.

The most striking fact in regard to these filaments is that the descending and ascending limbs are not separated from each other for about half their extent—the ventral half—but are connected by the continuation of their inner walls (*cp*, Fig. 50, Pl. LXXXVI, and Fig. 66, Pl. LXXXVIII).

There are no vascular connections between the filaments, but they are held together, as is usual in the genus *Arca*, by ciliated disks (*cd*, Fig. 66) arranged in a row on the anterior and posterior faces of the filament throughout its entire extent.

Fig. 66 represents a cross-section of four filaments. Three of these are cut at a point above the union of the ascending and descending limbs; a single one is cut lower down and passes through this connecting portion (*cp*).

The sections show the filament to be thin from before backward and wide from side to side. The elongated cells of the frontal epithelium (*f*) are uniformly ciliated and extend back for some distance from the end, the cilia gradually becoming shorter, as do the cells which bear them. At a corresponding point on either side, there are three or four cells seen in each section, which are longer than usual and bear long cilia (*lfl*). These are long ridges, or rows of cells, which are here cut in transverse section. They extend the whole length of the filament without any break, and their cilia do not serve to join contiguous filaments, but, as I believe, like the entirely similar rows in *Yoldia* (where there are two), are merely to prevent the main currents, carrying foreign particles, from entering between the filaments. Of course, currents of water do penetrate between the filaments to enter the water tubes of the gills, and thence proceed upward into the epibranchial chambers; but in all cases, so far as I have observed, the cilia of the rows, or lines, point obliquely *outward*, presenting their ends to foreign particles and keeping them out on the ciliated frontal epithelium while not being thick and heavy enough to prevent water from entering.

Peck (No. 16) has shown that in a position similar to this, though nearer the outer edge, in the gill filaments of *Anodon*, there was a *single* line of enlarged cells bearing very long cilia. Moreover, in *Dreissena* he found *two* lines of enlarged cells lying together, with no cells between, but with the two lines of cilia distinct. These cells, one appearing on either side in each section, he called the latero-frontal cells. In the latter case he distinguished a first and second latero-frontal cell.

The large ciliated cells, then, occur either in single rows or, I believe, in the majority of cases, in compound rows, showing several closely packed cells in cross-section. They do not always occupy a latero-frontal position. Considering these reasons, and the supposed function of their cells, I would designate them as the simple and compound straining lines.

In the case of *Dreissena* there are two simple, in *Yoldia* two compound, lines.

The inner part of the filament is composed of low cells whose boundaries are indistinct, excepting where an interfilamentar junction appears (*cj*). These are round patches of columnar cells bearing long cilia, arranged in the same region of the filament, at intervals throughout its length. The patches appear opposite each other on neighboring filaments, their cilia closely interlocked, and form a comparatively firm attachment. The cilia of these connecting discs are too closely packed together to allow of much motion, but by a high magnification, whether locked together or torn apart, the cilia of these patches show in a very feeble way the characteristic lashing in one direction and then the slow recovery of position. This motion is very slow indeed, each cilium moving independently of the others. This motion is of service, probably, in reuniting patches which have been separated from one another.

The chitinous lining (*ch*) is thin and at no place shows a marked thickening. It is slightly thicker just interior to the straining-line cells (at *ch*).

The membrane connecting the two limbs of the filament possesses walls, each of which is, as usual, made of a single layer of cells. They do not differ much in appearance from those of the inner part of the filament proper, with which they are continuous, except that they are slightly longer. These cells possess no cilia.

There is probably a continuous, vascular space between these walls, though in section they are, as in *Solenomya*, closely applied to each other. Here and there (*vs*) this space may be recognized.

THE GILL OF PECTEN IRRADIANS.

The gills of *Arca*, just described, and those of many other lamellibranchs, possess a smooth outer surface. In many forms, however, the lamellæ, both outer and inner, are thrown into definite folds, in order that their surface may be increased to facilitate aëration of the blood or the procuring of food, or both.

This folding appears in the lamellæ of the gills of *Pecten* (Fig. 86, Pl. XCII). The filaments are joined to each other only by cilia. The filament which occupies the salient angle of the fold (*sa*) is similar to the others in this form, although in some other cases (*Lima*, etc.) it is much enlarged. The filament at the reëntering angle in *Pecten* (*ra*) is greatly enlarged and peculiarly modified.

Fig. 86 represents a section passing through an entire fold of the gill. This fold is made up of fifteen filaments, not counting the specialized ones at the reëntering angle. The number varies slightly in different folds. All of the descending limbs of the filaments, forming one lamella of the gill, are cut on one side, and all the ascending, forming the other lamella, appear on the opposite side.

A section of a single filament is shown in Fig. 83. The chitinous layer is of nearly equal thickness, being thinner at the outer and inner edges, and thickest beneath the

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straining-line cells. The exterior epithelium is of long, large cells in the outer half of the filament, gradually merging into short cells, which are considerably widened. At the inner edge of the filament they again become columnar, but are not so long as at the outer edge.

Gland cells (*glc*) are present at the lateral boundaries of the frontal region (*f*) and are very conspicuous in certain specimens. They always occupy this position, and I have never seen them in the middle of the frontal epithelium, and only occasionally in other parts of the filament. These mucous cells vary in shape in different forms, sometimes being spherical, sometimes long and slender. They may be close to the base of the epithelium, surrounding them or pouring their contents out upon its surface. These various shapes and positions, more or less common in all lamellibranch gills, are shown in Fig. 85, a representation of the *inner* edges of four filaments of the gill of *Anomia*.

The cells of the epithelium immediately surrounding the gland cells in *Pecten* are seen to be crowded with yellow pigment granules (*pg*, Fig. 83).

At some little distance inward from the gland cells, appear in section four or five cells, bearing long cilia, crowding together to form the single compound straining line (*lfl*) on either side. These lines of cilia are inclined outward.

Fine cilia exist upon the frontal surface (*f*), becoming gradually shorter and finally disappearing as they reach the region of the gland cells. It is the movement of these cilia which causes the currents of water over the surface of the gills.

The chitinous layers, between which is the blood space of the filament, are lined on their inner surfaces by a distinct endothelium. Both the nuclei and protoplasm of its cells may be plainly seen (*en*). The blood channel, in which appear numerous nucleated blood corpuscles (*bc*), is divided by a transverse partition. Pelseneer describes this septum in *Pecten opercularis* as being chitinous in nature (though he does not use that term). I believe this septum (*p*) to be made of cells continuous with the endothelium of the walls of the blood cavity. Nuclei are very frequently present in it, often larger than the one represented in Fig. 83.

In the form referred to, Pelseneer also describes two large cells, one on either side of the frontal region—the latero-frontal cells of Peck—with their long cilia. Nothing of the kind exists in *Pecten irradians*.

The filament of the reëntering angle (Fig. 86, *ra*) is much enlarged. Its filamentous nature is recognized by the chitinous layers (*ch*), the compound straining line of ciliated cells (*lfl*), and the blood channel (*bc*). The epithelium of its walls is of a nearly uniform appearance. The descending and ascending limbs are connected throughout their entire length by a continuation of their walls (*ic*), which thus separate the interior space of the gill between the lamellae into a single channel for every fold. The walls of the partition are generally applied to one another in sections, but very frequently spaces are found between them which contain blood corpuscles. I believe that a vascular connection exists here between the two gill lamellæ, though it is said by Pelseneer not to exist in *P. opercularis*. Lacunar tissue also seems to be present (*lac*).

The ciliated junctions are peculiar and, so far as I know, are found only in *Pecten*. *Mytilus*, *Arca* (Fig. 66), etc., possess filaments joined to each other by ciliated discs, situated on the sides of the filaments. In *Pecten*, however, the ciliated junctions do not occur upon the sides of filaments, but only upon conical projections from their inner surfaces. These are shown in Fig. 84, a diagrammatic representation of

three filaments (*fil*) in a region where the projections occur. The conical points, which I would designate as ciliated spurs (*cs*), protrude abruptly into the water tube between the lamellæ of the gill.

A section passing transversely through the filaments, and in the long axis of a few of these ciliated spurs, is shown in Fig. 86, at *cs*. Their walls are seen to be merely a continuation of the single-cell-layered wall of the filament. They are closely interlocked by cilia. Their interior is filled up with a solid mass of cells whose nature I have not positively determined. In macerated specimens, they appear to be much elongated in the long axis of the spur, but sections failed to show this satisfactorily. These projecting spurs are very conspicuous in any macerated preparation of the gill of *Pecten*.

GILL OF VENUS MERCENARIA.

This folded gill is, in many ways, more complicated than that of *Pecten*. The filaments have a vascular connection with one another at their inner edges, spaces being left here and there to allow water to enter the water tube of the gill (Fig. 70, *w*, Pl. LXXXVIII). The great primary folds, marked off by the primary reëntering angles (ra_1), include about seventy filaments. These folds are sometimes divided, however, by a second reëntering angle (ra_2), into two secondary folds. There is no connection between the gill lamellae at this point. At the primary reëntering angle there is a partition between lamellae, consisting principally of muscle bundles (*mus*). Between these exists a blood channel (*br*). From these channels is sometimes given off into the water tube on either side of the partition a huge blood sinus (*pbs*). These are so large as to almost completely fill the space between the lamellæ.

Similar blood sinuses appear in other cases from an enlargement of the filament at the angle *fbs*, and may also be so great as to entirely fill the water tube. In regions where this condition is present, blood sinuses from the partitions are very small or absent.

Venus being a large form and quite active, must require a considerable amount of food and at the same time sufficient aëration of blood. The narrow filaments, not sufficiently large to contain much blood, seem to have been specialized for procuring food. These large blood sinuses may have been developed to provide for the diminished aëration in the filaments. Though they nearly fill the water tube, their thin walls are surrounded by water on all sides, probably in quantities sufficient for the purpose.

THE GILL OF OSTREA VIRGINIANA.

The gill of this very degenerate form is probably the most complex in the group. The lamellæ are thrown into a number of folds between each of the thick cross-partitions. The filaments may be seen almost everywhere in section (Fig. 76, Pl. XC) to have a vascular connection with one another at their inner edges. This is the case with all the filaments in the fold marked 2 in the figure to which reference has been made. Here the entire inner space of the fold is a blood sinus, with which the blood channel of every filament is continuous. In fold 1, three filaments at its outer extremity are connected by their inner edges. In fold 3, four filaments on the left are thus connected, and this common sinus is seen to be continuous with another, close under the wall of the water tube of the gill (*wt*).

GENERAL CONCLUSIONS IN REGARD TO THE GILLS.

1. The epithelium of the ventral edge of the gill plates in forms like *Nucula*, *Yoldia*, and *Solenomya*, and of the outer edge of the filament in all other lamellibranchs—morphologically the same thing—is specialized by the possession of "chitin," large ciliated cells, and gland cells. This of course does not apply to the deep-sea forms with a septum and no gill. This probably served in the ancestors of the group for the procuring of food as well as for aëration. However large the palps may be, they are certainly not sufficient in *Yoldia* for obtaining food. The gills here, and probably in other forms with plate gills, are extremely active in collecting food. Besides *Yoldia*, which I have observed, this function is evident in the others, from the presence of gland cells.

2. The single row of latero-frontal or straining cells, described by Peck in *Anodon*, and the two single cell rows of *Dreissena*, are not present in any of the marine forms which I have examined, with the exception of *Mytilus*. Here there is a single row of straining cells, and interiorly from these a row of many closely crowded, ciliated cells, which I have called the cells of the compound straining line. This arrangement, I believe, will be shown to be the most usual one in lamellibranch gills.

There may be one or two of these lines on each side of a filament including the simple lines of straining cells when they occur. I have never seen more than two. In *Solenomya* and *Anomia* there seems to be no such specialization, all the cells of the outer edge of the filament being of much the same size and equally ciliated.

I believe the function of these cells to be that of preventing foreign bodies in the water from entering between the plates or filaments of the gill, by means of their large cilia, while allowing currents of water to do so.

3. Gland cells were present at the sides of the frontal region, from one to three appearing in a section on either side. The forms in which they were seen in this position were *Solenomya*, *Arca*, *Mytilus*, *Pecten*, *Anodon*, *Venus*, *Mya*, *Anomia*, and *Ostrea*. I was not certain about the matter in *Yoldia*, though I believe that I have seen them in the gill of that form; and the fact that I have seen carmine grains firmly cemented into considerable masses on the gill of the living animal confirms this belief.

In *Mytilus* they generally appeared immediately interior to the outer row of latero-frontal cells. Lankester (No. 9) has described gland cells as occurring near the inner edge of the filament in *Ostrea edulis* quite as constantly as at the sides of the frontal region. In *Ostrea virginiana* I have found them present in this region in certain specimens, but not in all. When they occur they seem to be always nearly spherical, those outward being constantly elongated.

In some instances, gland cells occur on the inner edge of the filament, most noticeably in *Anomia*, where they are extremely abundant, very much more so than in the outer edge (Fig. 85).

4. I believe that an endothelial lining of the blood cavity of the filament or plate between the chitinous layers will be demonstrated in the majority, at least, of the Lamellibranchiata. I am quite certain of having observed it in *Yoldia*, *Pecten*, *Mytilus*, *Anodon*, *Venus* and probably in *Arca* and *Ostrea*. It is especially well shown in *Pecten* and *Yoldia*.

for a decrease in its size would lead to the extermination of the species. As we have already seen, at the same time that the development of these fixing muscles was going on there was a corresponding atrophy of the foot, which was no longer needed. But the foot, in the exercise of its locomotor function, had been dependent upon the great blood spaces of the mantle. These gradually came to be of no value and disappeared, and the generative gland pushed out into the great folds from its crowded position in the visceral mass and completely filled them.

Conclusions from a comparison of the branchial chambers.—The series of figures representing cross-sections shows at a glance the comparative size and conditions of the branchial chamber in the different forms.

The very large mantle chambers seem to be characteristic of those forms which are most active, as *Yoldia*, *Venus*, *Pecten*, and many others. In *Mytilus*, where the foot is much reduced in the adult, the surface of union of the mantle to the visceral mass is much greater, extending quite a distance down the side of the body, and so reducing the size of the branchial chamber. The foot has entirely disappeared in the oyster and the branchial chamber is much reduced, there being only room enough left for the short gills to lie between its folds (Figs. 2 and 4, Pl. LXXIX).

This footless form is a very degenerate one, and came from an active ancestor, with a fully developed locomotor foot. The comparison of the branchial chamber is of interest in this connection. In an active locomotor form, like *Venus* and others, there would be a great deal of oxidation going on in the tissues, and this would necessitate correspondingly great facilities for the aëration of the blood. Consequently we find the gills greatly developed, and a large branchial chamber is necessary in which they may be suspended. Then, also, there being a large expanse of thin-walled mantle, whose interior is made up almost entirely of great blood spaces, there is a good chance for the aëration of the blood in them, for water from the exterior bathes the mantle lobes as well as the gills, at least on their inner surfaces. It may be objected to this that when the shell is open and the foot protruded, the blood is almost entirely absent from the mantle and present in the foot. But when the animal is sufficiently buried in the sand the foot is contracted and the greater part of the blood is held by the mantle. The siphons, projecting into the water, are open, and a current is constantly running into the branchial chamber.

Suppose the power of locomotion to have been lost and the animal with its rudimentary foot to have been fastened by a byssus, as in *Mytilus*. Oxidation is lessened, for about the only tissues which sustain any wear are the large muscles which support the byssus from any shock which the animal may experience from the waves. The gills are proportionately smaller because less oxidation and less food are required; the mantle lobes lose the blood spaces and become filled with the sexual gland, and the branchial chamber is lessened in size.

The oyster has become fixed by a valve of its shell and has no byssus. The mantle blood spaces and the foot are both absent, and the form is capable of no movement whatever, excepting the closing of the shell and contraction of the mantle. The breaking down of tissues is thus reduced to a minimum and the need of the aëration of the blood is very slight indeed. So we find, as a result, an extremely small branchial chamber, admitting of small currents of water, for almost the entire space of the chamber is occupied by the gills.

of this membrane now grows and turns upward. There is *no mechanical bending of the filaments*, but a *growth* upward of their fused ends. After the outer edge of this membrane formed by the fused ends of the filaments has grown upward for some distance, the inner portion—that first formed—divides so as to mark out the ascending filaments as continuations of the descending ones. It is possible that this fusion of the ends of the descending filaments may not take place in the developing gills of forms like *Arca*, where in the adult the contiguous filaments are nowhere fused with one another.

Pelseneer (No. 17) now regards *Nucula* as the most primitive form. He believes *Anomia* and also the *Arcidæ* to be directly descended from forms with plate gills. As I have said, these relations may be the true ones, and yet it seems difficult to explain the structure of the gills of the former in terms of those of the latter. One might much more easily suppose, *a priori*, that the latter had developed from the filamentous type, perhaps by the degeneration of the ascending portion of its filament.

The point which I wish to make is shown in the accompanying cuts. Fig. 1 represents two gill plates of one side of the body of *Nucula*. The shaded portion represents the chitinous ventral edges. The ends of the plates here point downward and outward. Fig. 2 represents Pelseneer's hypothetical type, in which the plates are much elongated ventrally and have become more like filaments. In such a series Pelseneer could not place *Solenomya* or *Yoldia*, but had to throw them out because their plates, instead of extending their outer ends downward, extended them in quite the opposite direction.

Now come the simplest filamentous gills, those of *Arca*, Fig. 3. (I have figured the gills of *Arca pexata*.) In this the ascending filament (*afl*) is fully formed, and the difference between this condition and that of *Nucula* is seen to be very great, notwithstanding this hypothetical form.

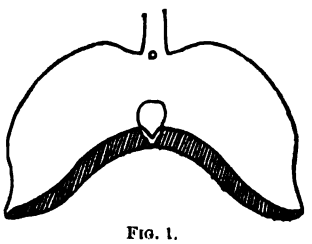

FIG. 1.

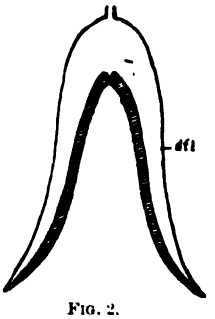

FIG. 2.

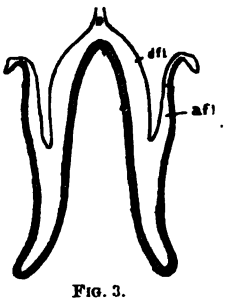

FIG. 3.

It is possible that the ascending limb of the filament is a new structure which has suddenly developed in those forms most closely connected with the forms with plate gills; if it is, however, merely a continuation outward of the descending filament, it seems as if we ought to regard the gill plate of *Nucula* as being homologous, not alone to the descending limb of a filament, as Mitsukuri has done, but to both descending and ascending limbs.

Very frequently, however, openings appear between the filaments. In fold 3 this is the case with the majority of the filaments in the plane of this section. Here water may enter between the filaments into the interior of the fold and thence into the water tube of the gill (*wt*).

A filament has much the same structure as in *Pecten*, excepting that the chitinous layer is abruptly thickened a short distance from its outer edge (*ch*). There is no constant septum across the blood channel of the filament. I believe that an endothelium is present, but can not be positive.

The surface epithelium is of columnar, ciliated cells in the frontal region (f_1). At its lateral edges appear gland cells in the usual position (*glc*). They are seldom seen on the inner edge of the filament in *O. virginiana*, described by Lankester (No. 9) as being as numerous here as at the side of the frontal region in *O. edulis*. The gland cells are not spherical, but much elongated in the specimens which I have examined.

As in *Pecten*, certain cells crowd together a little distance inward from the gland cells, to form the compound straining line. The ciliated lines (*lfl*) do not interlock, but touch each other and form a barrier to foreign particles which might otherwise be carried into the water tube.

The filament at the reëntering angle (*ra*) is very greatly modified. It is essentially similar, whether or not it is extended across to the opposite lamella of the gill to form the thick partitions between the water tubes. The structures showing it to be morphologically a filament are the ciliated frontal epithelium (f_2), the chitinous layer, here modified into two extremely large and thick rods (ch_2), and, in most cases, a blood channel interior to these.

The filaments next these at the angle of the fold are broadened and shortened; their chitinous layer is much enlarged and has become rod-like on either side. In fact, they offer a transitional stage between the ordinary filament and the extremely modified filament at the reëntering angle of the folds. Such a transitional filament is that represented at *tf*.

The partitions connecting the gill lamellæ are lined by an epithelium of cuboidal cells (*ep*), continuous with that which lines the remaining walls of the water tube. The interior of the partition consists of many longitudinal and cross muscle fibers (*mus*), and between these often lie masses of large circular cells (*pc*), which I have only seen in the partition. A considerable portion of the partition is often occupied by blood spaces (*bv*).

Muscle fibers also occur in masses interior to those reëntering angle filaments not connected with a partition. They seem to be extended in the long axis of the gill.

GENERAL CONCLUSIONS IN REGARD TO THE GILLS.

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PLATE LXXXIV.

Mytilus edulis—Common mussel:

FIG. 33. Transverse, vertical section in region of mouth, *mo; l*, liver; *ol*, outer lamella of outer gill; *il*, inner lamella of inner gill; *m*, thickened mantle, containing sexual gland; *pl*, anterior palp; *me*, mantle edge, joined anteriorly (*m*) down to a position almost beneath the mouth; *ar*, anterior retractor of foot; *f*, foot extending forward and flattened dorso-ventrally.

FIG. 34. Same in region of stomach, *s; p*, anterior end of pericardium; *l*, liver; *g*, generative mass. (The visceral mass is seen to be relatively very small.)

FIG. 35. Same, in region just anterior to base of foot; *h*, anterior end of heart; *w*, water tube between gill lamellæ; *ar*, anterior foot-retractors close together, and in the following figures are seen to run between the only retractor muscles of the foot, *fm; i*, intestine.

FIG. 36. Same, in region of base of foot, *f; fm*, posterior retractors of foot, running directly upward to become attached to shell; *ar*, anterior-foot retractors, running between posterior retractors to become attached to byssus organ.

FIG. 37. Same, in region of byssus organ and byssus, *b; h*, heart, containing rectum; *r* (auricles indicated at sides); *bm*, byssus muscles attached to shell and combining to support byssus organ.

FIG. 38. Same, in region of posterior end of heart, *h*.

PLATE LXXXV.

Mytilus edulis—Common mussel:

FIG. 39. Vertical, transverse section just in front of posterior adductor; *bm*, most posterior of byssus muscles; *ab*, posterior region of abdomen or visceral mass; *r*, rectum.

FIG. 40. Same, in region of anterior end of posterior adductor; *i*, intestine; *r*, rectum; *pa*, posterior adductor; *ab*, extreme posterior end of visceral mass.

FIG. 41. Same, in region of posterior end of posterior adductor.

FIG. 42. Side view of chief muscle system of *Mytilus; aa*, anterior adductor; *pa*, posterior adductor; *ar*, anterior foot-retractors, running backward between posterior foot-retractors, or muscles suspending the foot, *fm*, and joining the byssus organ. The muscles of the foot itself are entirely free from any connection with these. This organ, *f*, and its retractors, *fm*, may be removed from all the other muscles without anywhere injuring them; *bm*, byssus muscles; *bys*, byssus.

Pecten irradians—Scallop:

FIG. 43. Vertical, transverse section in region of mouth; *l*, liver; *mo*, large mouth opening into very wide œsophagus; *ap*, anterior palp; *fr*, part of fringe of anterior lip, the median portion of the two anterior palps.

FIG. 44. Same, in region of stomach, *s*, the walls of which are extremely uneven and folded; *i*, intestine.

PLATE LXXXVI.

Pecten irradians—Scallop:

FIG. 45. Vertical, transverse section in region of heart; *p*, large pericardium; *no*, opening at base of pericardium into the large nephridium, *n*, below; *i*, intestine; *g*, generative mass; *a*, portion of the adductor muscle; *ven*, ventricle of heart with rectum, *r*, attached to its dorsal wall; *au*, auricle of heart running downward to connect with large vein from gills, *gl*.

FIG. 46. Same, in middle region of adductor, *da*, small, closely contracted portion of adductor with dark, striated fibers; *a*, main portion of adductor, composed of white fibers; *gm*, membrane suspending gills.

FIG. 47. Same, upper, posterior portion of adductor, showing position of greatly contracted dark portion, *da*, and mantle edges, *me*, not fused above.

Yoldia limatula:

FIG. 48. Horizontal section through inner edges of gill plates in *Yoldia* (Fig. 81, *d*); *ml*, median line; *a*, space in interior of a plate; *b*, space between plates; *mf*, muscle fibers, occasionally showing nuclei, in interior of plate; *lac*, lacunar tissue.

Mytilus edulis—Common mussel:

FIG. 49. Diagram of lamellæ of two gills; *br*, blood vessel in ends of outer lamella, continuous throughout all filaments; *ilc*, interlamellar connection; *ifc*, ciliated, interfilamentar connections.

It is possible that the oyster came, in its degeneration, through a form in many respects similar to *Mytilus*, from some active ancestor with a locomotor foot. Judging from the most primitive of existing lamellibranchs—*Nucula*, *Solenomya*, etc.—the immediate ancestors of the group probably possessed a greatly developed foot. *Ostrea*, therefore, gives evidence of having departed much further from this ancestor in its degeneration than has *Mytilus*. This latter form, in turn, is less changed by its mode of life, and, noting here and there a form on the way to the most archaic, *Venus*, *Arca*, *Nucula*, still less and less so.

And yet the foot is too variable an organ to be made an exclusive means of classification or even the chief one. *Anomia* has lost the foot on account of its fixed habit, and yet it possesses some structures which indicate a more primitive position for the form than the one commonly supposed for it. Pelseneer goes so far as to place it immediately next the primitive forms with plate gills.

But if there is one organ of lamellibranchs which is most subject to variation by secondary modification, it is the gill. While it is an important organ, it seems as if it were hardly possible to use it as a basis of classification for the whole group, as Pelseneer has done. In a group where any and all organs are so subject to secondary modification, there must be a careful comparison of many of them, instead of one or two, perhaps; and even a complete knowledge of the comparative anatomy, which we by no means possess, can not be safely used as a basis for classification without the aid of comparative embryology, which is still less known.

The phylogeny of the gills.—It is generally considered that the anatomy of those lamellibranchs which possess plate gills (*Nucula*, *Solenomya*, etc.) shows conclusively that the group which they form must be the most primitive one of all living lamellibranchs. More especially since the appearance of Mitsukuri's paper on these plate gills (No. 13) has this been the general opinion. Their anatomical and histological similarity to certain gasteropod gills is one of the strong points for such a belief.

But there is a very great gap between these plate gills and the strictly filamentous type, which, it seems to me, can not be explained by any facts which we now possess, either anatomical or embryological.

In his *Challenger* report on the Mollusca, Pelseneer attempts to show by a series of diagrams the phylogenetic development of the gill. Beginning with *Malletia*, with plates extending laterally, he derives *Nucula* from it, in which the outer end of the plate is turned slightly downward. He now has to interpolate an hypothetical gill in which the plates have developed ventrally for some distance, but which shows no sign of an ascending portion. The next stage which he takes in his phylogenetic development is represented by the gill of *Arca*, in which there is a fully formed ascending limb of the filament and neither limb shows anything plate-like, but both are cylindrical. But right here is the gap referred to, and it would still remain very great even if his hypothetical gill just preceding it were really known to exist.

This scheme of historical development was molded upon what little knowledge we have of the ontogeny of the gill. This knowledge, except for a few fragmentary observations, we owe to Lacaze-Duthiers (No. 7). In his study of the development of the gill of *Mytilus*, he shows that the gills appear from a ridge running horizontally along the side of the body, from which rods grow out and descend ventrally. These are separate from one another and become the filaments. After attaining to a certain length their enlarged ends fuse together and form a solid membrane. The lower edge

PLATE LXXXVIII—Continued.

Yoldia, Venus, Pecten, Ostrea:

FIG. 67. A few spermatozoa, to show variation in appearance in different forms and in the same individual. "Tails" represented about half length. *a*, spermatozoön of *Yoldia*; *b*, of *Venus*, normal shape; *c*, of *Venus*, a very usual abnormality; *d*, of *Pecten*, normal shape; *e*, of *Ostrea*; *f*, of *Pecten*, an abnormal condition.

Pecten irradians—Scallop:

FIG. 68. Mouth fringe on edges of palps. A, bunch of fringe, seen from outer surface of lip; B, small portion of fringe of lip magnified, view of inner surface.

Yoldia limatula:

FIG. 69. Digestive tract of *Yoldia*. *m*, mouth; *s*, stomach; *i*, intestine; *pa*, posterior adductor; *r*, rectum.

Venus mercenaria—Quahog:

FIG. 70. Cross-section of single fold of gill; *ra*, reëntering angle of fold; *fil*, filaments; *mus*, muscle fibers of partition connecting lamellæ of gills; *br*, blood-vessel in partition; *pbs*, great blood sinus from partition wall, sometimes almost filling half of a water tube of gill; *fbs*, blood sinus in inner edge of the filament, at the secondary reëntering angle of fold. This sometimes becomes, with the one opposite in the other lamella, as large as the partition sinus in the figure, the latter disappearing; *mus*, muscle fibers at inner edges of filaments.

PLATE LXXXIX.

Pecten irradians—Scallop:

FIG. 71. Generative gland; *ov*, ovary; *t*, testis; *ep*, ciliated epithelium on surface of visceral mass; *glc*, gland cells; *bm*, basement membrane; *ct*, tissue of irregular cells beneath epithelium; *fep*, follicular epithelium; *d*, ciliated ducts, the one in the testis containing spermatozoa, and on its walls a gland cell is shown; *br*, blood vessel.

Ostrea virginiana—Oyster:

FIG. 72. Hermaphrodite gland; *ep*, ciliated epithelium of surface of visceral mass; *glc*, gland cell; *fep*, follicular epithelium, apparently giving rise only to ova; *ov*, ovum; some are free, some attached to walls of follicle; *sper*, apparently ripe spermatozoa completely filling lumen of follicles; spermatozoa and ova occupy *same follicles*.

Venericardia borealis:

FIG. 73. Section horizontally across byssus organ; *fd*, folded secreting surface; *bs*, byssus secretion in fold; *bm*, muscles of byssus cut transversely; *c*, large clear cells near inner edges of folds.

FIG. 74. Excretory epithelium of one of folds of same, more magnified; *cc*, columnar cells over the distal ends of which is a striated layer probably of the byssus secretion, but appearing much like cilia; *bs*, evident byssus secretion; *lc*, transparent cells at base of fold, without nuclei, outer edges indistinct and striated; *bv*, blood vessel with endothelial lining.

PLATE XC.

Pecten irradians—Scallop:

FIG. 75. Section across mouth fringe; *ep*, rod-like epithelial cells bearing long cilia; *bm*, basement membrane; *glc*, large, elongated gland cells, the nuclei of some being visible; *bv*, blood vessel with endothelial lining.

Ostrea virginiana—Oyster:

FIG. 76. Transverse section of gill; 1, 2, 3, 4, folds of lamella between two lamellar partitions; f_1, ciliated frontal epithelium of filament of fold; f_2, ciliated epithelium of frontal region of modified filament, at reëntering angle of fold; ch_1, chitinous rods in filament of fold; ch_1, chitinous rods of modified filament; *ra*, reëntering angle of fold; *lft*, cilia of cells of straining line; *glc*, gland cells; *mus*, muscle fibers; *pc*, spherical cells in partition connecting gill lamellæ; *wt*, water tube; *bc*, blood corpuscles; *bv*, blood vessel of partition; *ep*, epithelium of partition; *tf*, filament, transitional between filament of fold and filament of reëntering angle.

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PLATE XCIII—Continued.

Venus mercenaria—Quahog:

FIG. 93. Longitudinal vertical section through posterior mantle region, *Venus*; *pa*, posterior adductor; *r*, rectum; *cl*, cloacal region; *epc*, epibranchial chamber; *ig*, inner gill; *brm*, branchial membrane; *brc*, branchial chamber; *me*, mantle edge.

Mya arenaria—Long clam:

FIG. 94. Longitudinal, vertical section of posterior mantle region in *Mya*; *pa*, posterior adductor; *r*, rectum; *cs*, cloacal siphon; *bs*, branchial siphon; *brm*, fold in position of branchial membrane of *Venus*; *ig*, inner gill; *brc*, branchial chamber; *me*, mantle edge; *sf*, folds in wall of partly contracted siphon.

Mytilus edulis—Common mussel:

FIG. 95. Anterior end of body of *Mytilus*, cut off by vertical transverse section just behind mouth, to show position of palps; *ar*, anterior retractor muscles; *ip*, inner palp; *op*, outer palp; *ig*, inner gill; *m*, mantle; *mo*, mouth.

PLATE XCIV.

Venus mercenaria—Quahog:

FIG. 96. *Venus*, life size, right valve of shell and mantle fold being removed; *aa*, anterior adductor muscle; *pa*, posterior adductor; *afr*, anterior foot-retractor muscle; *pfr*, posterior foot-retractor; *lg*, ligament of shell; *hg*, hinge of shell; *epc*, epibranchial chamber; *h*, heart seen beneath; *pl*, anterior palp; *f*, foot; *me*, mantle edge; *ig*, inner gill; *su*, portion of mantle remaining on sides of bases of siphons.

Ostrea virginiana—Oyster:

FIG. 97. *Ostrea*, life size, right valve of shell and mantle fold being removed; *lg*, ligament of shell; *ip*, inner palp; *ig*, inner gill; *n*, nephridium under the adductor muscle; *me*, mantle edge; *c*, cloacal region; *r*, rectum; *a*, adductor muscle; *h*, heart seen beneath the pericardium.

PLATE LXXXII—Continued.

Venus mercenaria—Quahog—Continued.

FIG. 18. Same, in region of middle of posterior adductor, *pa;* *m*, thickened muscular mantle edge; *ws*, lower wall of branchial siphon seen posterior to branchial membrane, *brm*. (This represents the anterior surface of the section.)

FIG. 19. Same, in region of base of siphon, *us*, upper or anal siphon; *ls*, lower or branchial siphon: *r*, point where branchial siphon remains continuous with mantle; *m*, mantle continued across below siphons; *ss*, siphonal septum.

FIG. 20. Same, just posterior to last. Siphons still beneath posterior adductor, *pa*, separated from mantle, which is yet continuous beneath them.

FIG. 21. Same, posterior to last, mantle not continuous beneath siphons. Lumen of branchial siphon, *ls*, assumes oval outline.

FIG. 22. Same, through free siphons.

Mya arenaria—Long clam:

FIG. 23. Vertical, transverse section in region of anterior adductor, *a*; *me*, thick mantle edge; *c*, cuticle from mantle edge; *m*, mantle below adductor; branchial chamber closed in by concrescence of mantle edges below; *f*, foot much flattened laterally.

PLATE LXXXIII.

Mya arenaria—Long clam:

FIG. 24. Vertical, transverse section in region of anterior end of visceral mass; *me*, mantle edge; *oe*, thick-walled œsophagus; *op*, outer palp; *ip*, inner palp; *m*, mantle; *g*, generative mass; *l*, liver.

FIG. 25. Same, in region of anterior end of stomach, *s*; *ig*, inner gill; *og*, outer gill; *ec*, epibranchial chamber; *i*, intestine; *cst*, crystalline style running forward on ventral side of abdomen.

FIG. 26. Same, in region of posterior end of stomach; *bv*, blood vessel; *cst*, crystalline style, originating from ventral wall of stomach, *s*, and running on right side of body to bottom of visceral mass. It then turns forward, and is shown in section in the preceding figure.

FIG. 27. Same, in region of heart, *h;* *n*, nephidium; *ol*, outer lamella of outer gill; *mf*, muscle fibers in generative gland.

FIG. 28. Diagram to show plane of sections through folded gills of *Mya* and *Venus*, explaining reason of folded appearance in vertical sections of the whole animal.

FIG. 29. Section just anterior to base of siphons, the anterior face of section; *r*, rectum, below plane of section, opening into continuation of epibranchial or the cloacal chamber, *cl;* *gl*, outer lamella of gill in concrescence with mantle. Gills here form complete septum between branchial and epibranchial chambers; *bs*, base of branchial siphon below plane of section; *ws*, siphonal walls; *brm*, fold at anterior end of siphonal septum, probably representing branchial membrane of *Venus*, *Mactra*, etc.; *ct*, jelly-like layer, clothing posterior end of mantle and extending out over siphons.

FIG. 30. Same, through base of siphons, right side cut a little deeper than left. The thickened mantle walls, *ws*, in the previous figures, become here the siphonal walls, *ws*, and are now much thicker; *cl*, upper end of cloaca opening below into anal siphon, *us;* *ss*, siphonal septum.

FIG. 31. Same, through siphons at a distance from mantle; *br*, blood vessel. A similar vessel is present above the anal siphon.

Mytilus edulis—Common mussel:

FIG. 32. Transverse, vertical section through anterior end of body; *l*, liver mass; *og*, outer gill; *ig*, inner gill; *m*, thickened mantle, containing sexual gland. That portion on the median line has been drawn in greatly on killing, and thus appears in section; *ar*, anterior retractor; *pl*, palp; *aa*, anterior adductor; *me*, mantle edge.

PLATE LXXXVI—Continued.

Arca (Argina) pexata:

FIG. 50. Single gill filament, *il*, inner lamella; *ol*, outer lamella; *ifc*, interfilamentar connection.

Cardita borealis:

FIG. 51. Vertical, transverse section in region of pedal ganglion; *s*, stomach; *l*, liver; *g*, generative mass; *ig*, inner gill; *pp*, posterior palp; *me*, mantle edge; *pg*, pedal ganglion, with cerebral commissure running dorsally.

PLATE LXXXVII.

Yoldia limatula:

FIG. 52. Removed from shell; right mantle fold dissected off; *aa*, anterior adductor; *pa*, posterior adductor; *l*, liver mass and generative gland, on the surface of which may be seen the loop of the intestine, *i*; *p*, large palp, extending beneath visceral mass. At its posterior end springs the appendage *ap*; *g*, gill, extending from posterior end of palp to base of siphons, *s*; *me*, mantle edge; *f*, foot; *d*, ventral disc of foot.

FIG. 53. Transverse section across siphon of *Yoldia*, showing portion of wall of anal, *as*, and branchial siphons, *br*, including a portion of siphonal septum, *ss*; *c*, covering of exterior of siphons; it is more or less transparent, contains numerous nuclei, and, at places, indications of elongated cell boundaries; *trm*, regularly arranged bundles of transverse muscles in walls of both siphons and siphonal septum; *lm*, numerous bundles of longitudinal muscles (here cut transversely), alternating regularly with the transverse layers.

Ostrea virginiana—Oyster:

FIG. 54. Portion of secretory epithelium of nephridium in *Ostrea*; *exc*, excretory cells, with deeply stained bases and transparent globular free ends; *l*, lumen of excretory tube, into which break off fluid globular ends of cells. Many of these contain a small stained body.

Mactra solidissima:

FIG. 55. Crystalline style. End teased off in spiral from softer central axis, *ca*.

Pecten irradians—Scallop:

FIGS. 56 and 57. Concretions showing concentric structure, from excretory cells of nephridium.

FIG. 58. Excretory cell from nephridium; *con*, distally placed concretion (these all show a deeply stained central portion of various shapes and sizes); *vac*, numerous small vacuoles; *nuc* nucleus.

FIG. 59. Elongated cells from same, containing numerous spherical vacuoles of varying sizes.

FIG. 60. Segmenting eggs found in nephridium.

Solenomya velum:

FIG. 61. Single siphonal opening in mantle. A, walls not bent; B, walls bent to form upper, *as*, and lower siphonal openings, *bs*; *t*, tentacles.

Ostrea virginiana—Oyster:

FIG. 62. Transverse section of palp of *Ostrea*, near ventral or outer edge. Inner surface thrown into ciliated ridges or folds, *f*. In this region these consist of two secondary folds, *sf*; *ct*, irregular membrane at base of folds; *fc*, fat cells.

FIG. 63. Same, midway between ventral edge and base, showing difference in character of folds, *f*.

FIG. 64. Same, at base. No secondary folds. Supporting tissue at base of folds much thicker, *ct*; *bv*, blood vessel.

PLATE LXXXVIII.

Ostrea virginiana—Oyster:

FIG. 65. Striated muscle fibers in auricle of heart; *smf*, striated muscle fibers, generally, if not always, attached to thick, homogeneous, supporting membrane of wall, *sm*; *a*, protrusion of supporting membrane through epithelium of wall to exterior; *pgc*, pigment cells; *v*, vacuolated epithelial cells scattered throughout muscle fibers.

Arca (Argina) pexata:

FIG. 66. Cross-section of gill filaments; *glc*, gland cells; *lfl*, cilia of straining line; *ch*, chitin; *cj*, ciliated junction; *f*, frontal epithelium; *vs*, vascular space between walls connecting lower part of descending and ascending filaments. This filament was cut lower down than the other three represented in the figure (see Fig. 50).

PLATE XCI.

Solenomya velum:

FIG. 77. Cross-section of two gill plates; *glc*, gland cells; *re*, ciliated, columnar cells of thickened ventral edge of plate; *ch*, chitinous rods, lined interiorly by endothelium; *w*, cells of interior walls of plate.

Yoldia limatula:

FIG. 78. Diagrammatic view of ventral edges of gill plates; *p*, ventral edges of plates; *gr*, ventral groove; *cj*, ciliated junction between plates.

FIG. 79. Vertical section across gill plate; *e*, frontal epithelium bearing very large cilia; *r*, ridge of cells forming first compound straining line; *t*, cells forming second compound straining line; *ch*, chitin, inclosing *b*, a blood-channel lined by endothelial cells; *s*, blood space of interior of plate, bridged across by numerous branching lacunar cells, *lac; f*, folds in wall of plate; *d*, blood space at dorsal edge of plate.

FIG. 80. Cross-section of dorsal ends of plates of gill; *lac*, numerous lacunar cells; *ep*, epithelium on surface of supporting membrane of gills; *m*, muscles of same.

FIG. 81. Diagram of plates of gills showing planes of sections; *a*, plane of Fig. 79; *b*, of Fig. 82; *c*, of Fig. 80; *d*, of Fig. 48, Pl. LXXXVI.

FIG. 82. Sections of plates of gill, *Yoldia*, in plane *f*, Fig. 81, showing lines of ciliated junction, *cj*; *e*, lateral edge of plates; *s*, space between edges of plates where ciliation is absent; *lac*, lacunar tissue; *ep*, epithelium of supporting membrane of gills; *m*, muscles of same.

PLATE XCII.

Pecten irradians—Scallop:

FIG. 83. Cross-section of single filament, gill of *Pecten*; *f*, ciliated frontal epithelium; *glc*, gland cells; *pg*, pigment in region of gland cells; *lfl*, cells of compound straining line; *ch*, chitin; *p*, septum of filament showing nucleus.

FIG. 84. Diagram of portions of three filaments of gill, to show nature of ciliated spurs, *cs*, which form means of interfilamentar union; *fil*, filament.

Anomia simplex:

FIG. 85. Inner ends of filaments of *Anomia*, to show gland cells.

Pecten irradians—Scallop:

FIG. 86. Cross-section of gill of *Pecten*; *ra*, reëntering angle of gill folds; *sa*, filament at salient angle of gill fold; *ch*, chitin of modified filament of reëntering angle; *lfl*, straining line of modified filament; *bc*, blood space of modified filament; *w*, walls of modified filament, forming interlamellar union; *lac*, lacunar tissues; *cs*, ciliated spurs connecting filaments.

PLATE XCIII.

Mytilus edulis—Common mussel:

FIG. 87. Siphonal region of mantle in *Mytilus* seen from behind; *co*, cloacal opening; *brm*, branchial membrane; *me*, mantle edge.

FIG. 88. Same, seen from in front; *co*, cloacal opening; *og*, outer gill; *brm*, branchial membrane; *m*, mantle.

Ostrea virginiana—Oyster:

FIG. 89. Posterior region of mantle in *Ostrea*, seen from behind; *r*, rectum, opening into upper end of cloacal chamber; *brp*, concrescence of mantle edges above gills; *ig*, inner gill; *og*, outer gill; *me*, mantle edge.

Venus mercenaria—Quahog:

FIG. 90. Posterior region of mantle in *Venus*, view of base of siphons; *og*, outer gill; *bm*, branchial membrane; *me*, mantle edge.

Solenomya velum:

FIG. 91. Gills of one side of body in *Solenomya; m*, supporting membrane; *gr*, groove on median line opposite supporting membrane.

Yoldia limatula:

FIG. 92. Gills of one side of body in *Yoldia; m*, supporting membrane; *gr*, groove on midline of ventral surface.

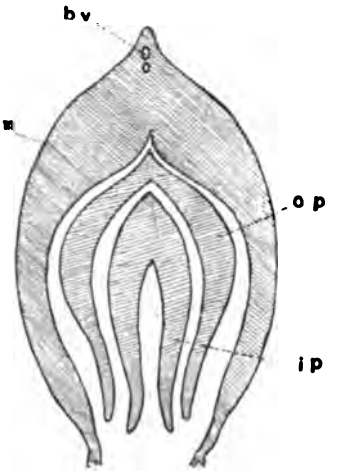


Fig. 1

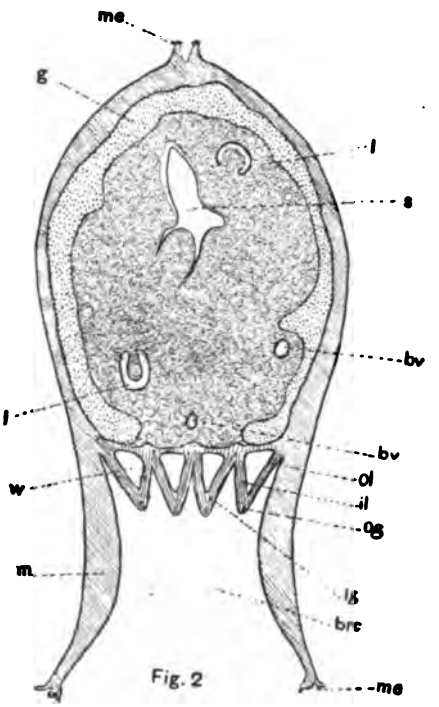


Fig. 2

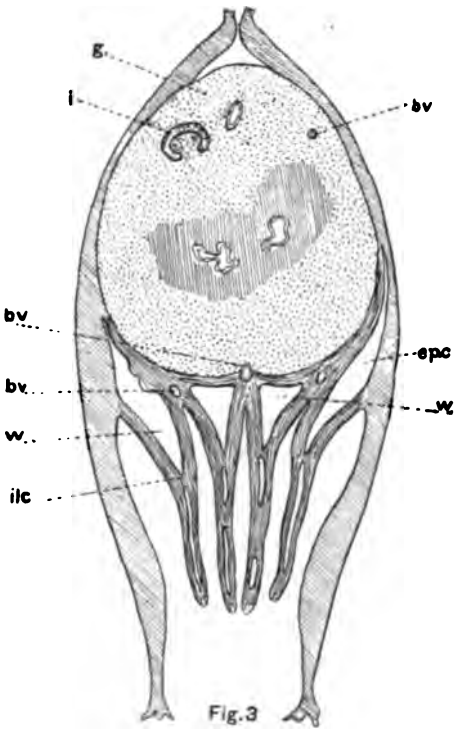


Fig. 3

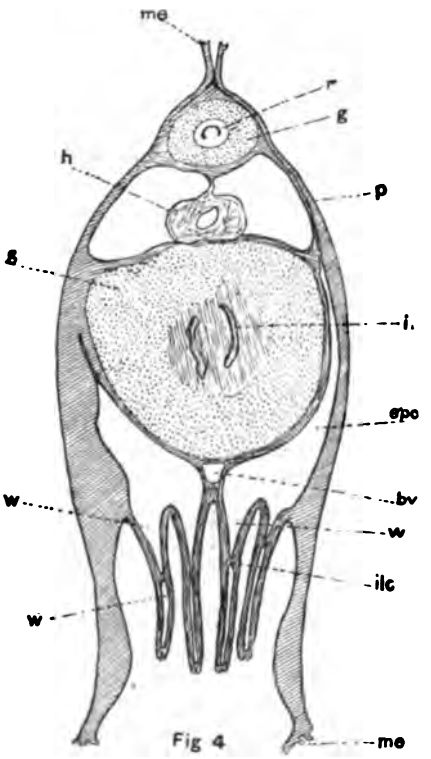
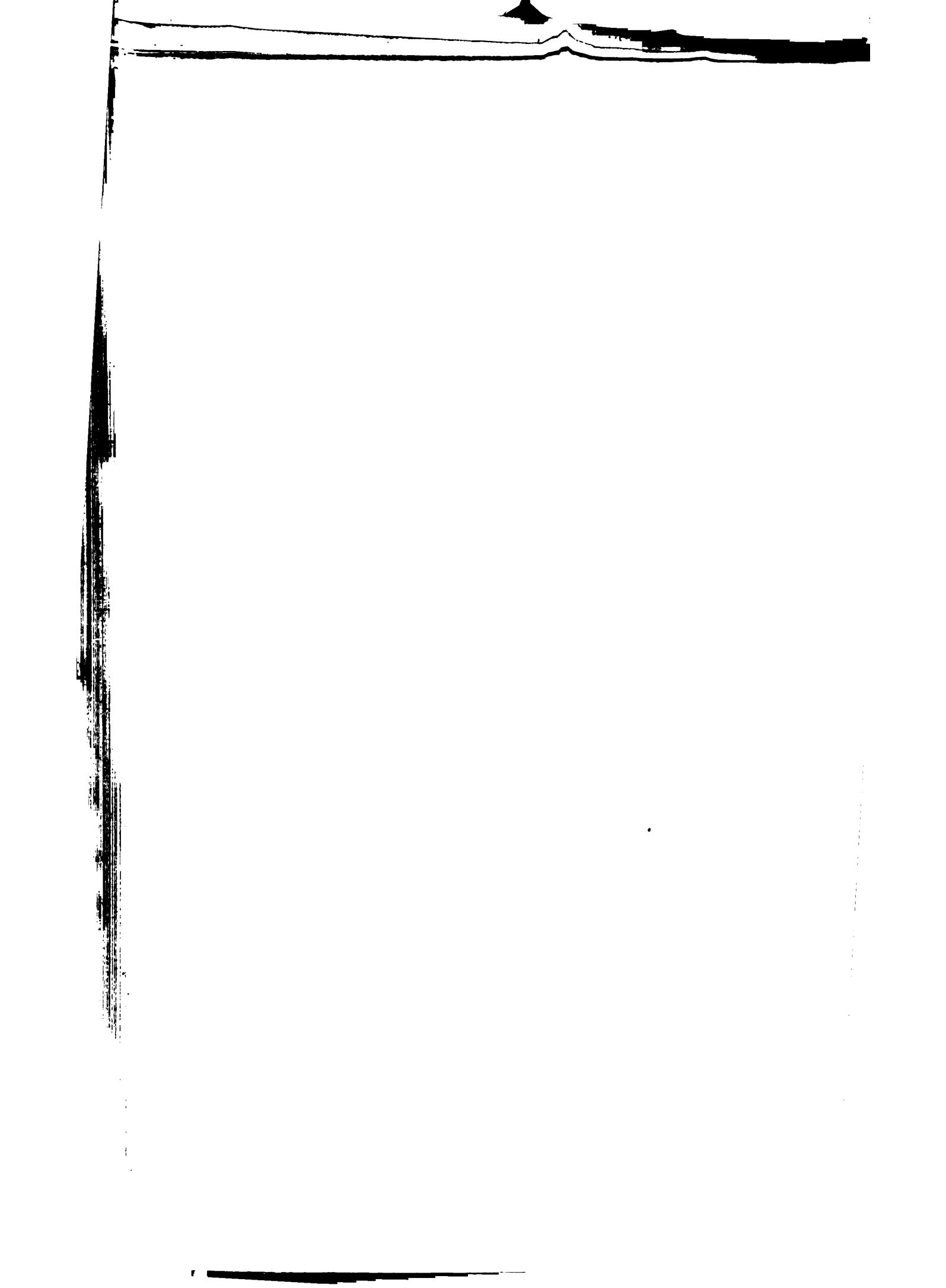


Fig 4

Kellogg del.



It is possible that the oyster came, in its degeneration, through a form in many respects similar to *Mytilus*, from some active ancestor with a locomotor foot. Judging from the most primitive of existing lamellibranchs—*Nucula*, *Solenomya*, etc.—the immediate ancestors of the group probably possessed a greatly developed foot. *Ostrea*, therefore, gives evidence of having departed much further from this ancestor in its degeneration than has *Mytilus*. This latter form, in turn, is less changed by its mode of life, and, noting here and there a form on the way to the most archaic, *Venus*, *Arca*, *Nucula*, still less and less so.

And yet the foot is too variable an organ to be made an exclusive means of classification or even the chief one. *Anomia* has lost the foot on account of its fixed habit, and yet it possesses some structures which indicate a more primitive position for the form than the one commonly supposed for it. Pelseneer goes so far as to place it immediately next the primitive forms with plate gills.

But if there is one organ of lamellibranchs which is most subject to variation by secondary modification, it is the gill. While it is an important organ, it seems as if it were hardly possible to use it as a basis of classification for the whole group, as Pelseneer has done. In a group where any and all organs are so subject to secondary modification, there must be a careful comparison of many of them, instead of one or two, perhaps; and even a complete knowledge of the comparative anatomy, which we by no means possess, can not be safely used as a basis for classification without the aid of comparative embryology, which is still less known.

The phylogeny of the gills.—It is generally considered that the anatomy of those lamellibranchs which possess plate gills (*Nucula*, *Solenomya*, etc.) shows conclusively that the group which they form must be the most primitive one of all living lamellibranchs. More especially since the appearance of Mitsukuri's paper on these plate gills (No. 13) has this been the general opinion. Their anatomical and histological similarity to certain gasteropod gills is one of the strong points for such a belief.

But there is a very great gap between these plate gills and the strictly filamentous type, which, it seems to me, can not be explained by any facts which we now possess, either anatomical or embryological.

In his *Challenger* report on the Mollusca, Pelseneer attempts to show by a series of diagrams the phylogenetic development of the gill. Beginning with *Malletia*, with plates extending laterally, he derives *Nucula* from it, in which the outer end of the plate is turned slightly downward. He now has to interpolate an hypothetical gill in which the plates have developed ventrally for some distance, but which shows no sign of an ascending portion. The next stage which he takes in his phylogenetic development is represented by the gill of *Arca*, in which there is a fully formed ascending limb of the filament and neither limb shows anything plate-like, but both are cylindrical. But right here is the gap referred to, and it would still remain very great even if his hypothetical gill just preceding it were really known to exist.

This scheme of historical development was molded upon what little knowledge we have of the ontogeny of the gill. This knowledge, except for a few fragmentary observations, we owe to Lacaze-Duthiers (No. 7). In his study of the development of the gill of *Mytilus*, he shows that the gills appear from a ridge running horizontally along the side of the body, from which rods grow out and descend ventrally. These are separate from one another and become the filaments. After attaining to a certain length their enlarged ends fuse together and form a solid membrane. The lower edge

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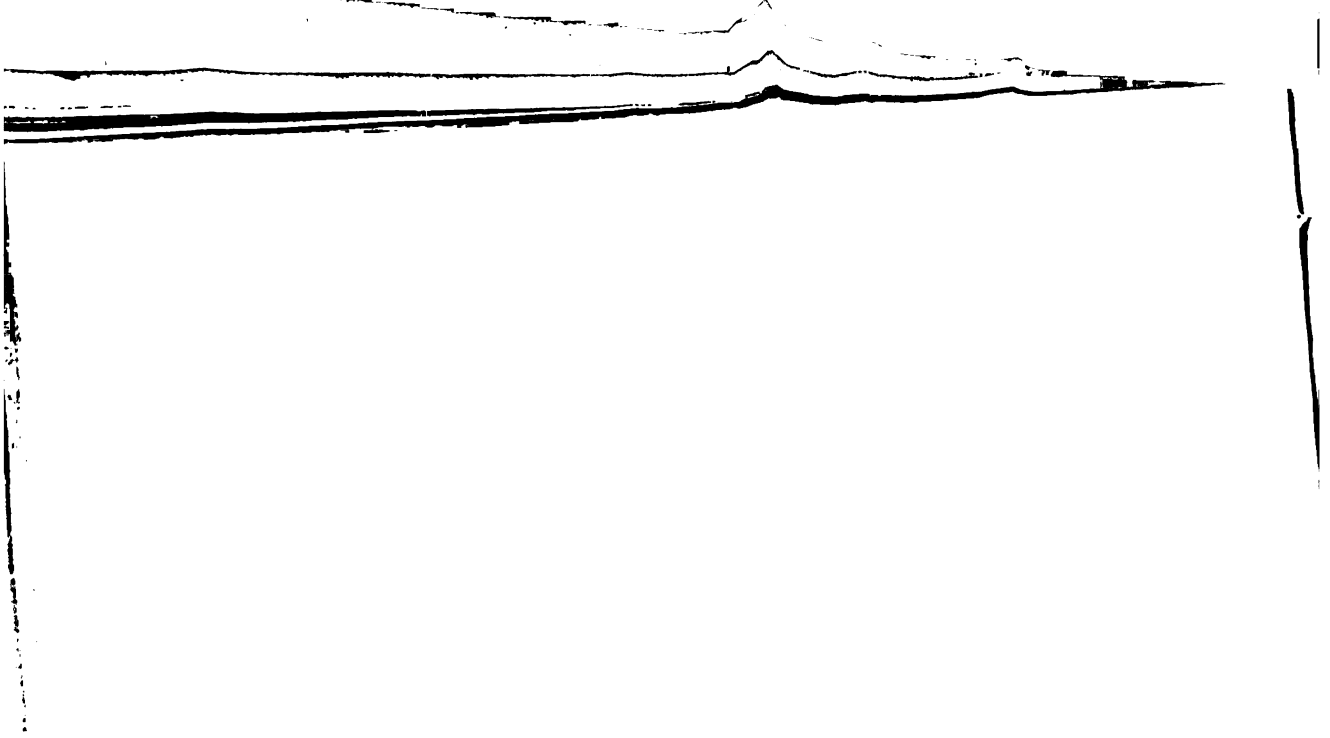


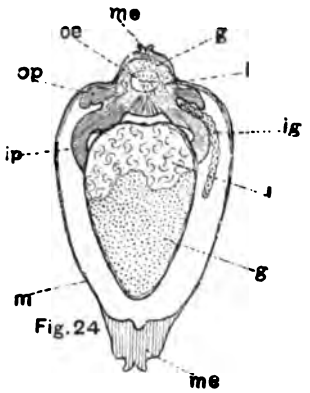


Fig.24

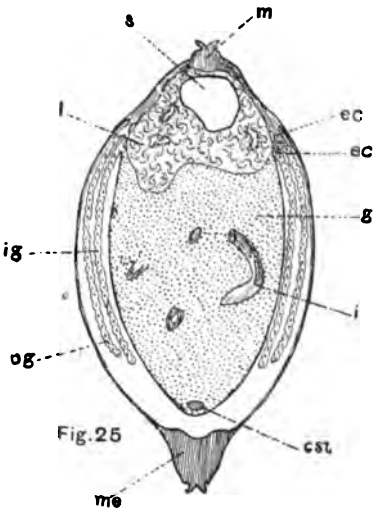


Fig.25

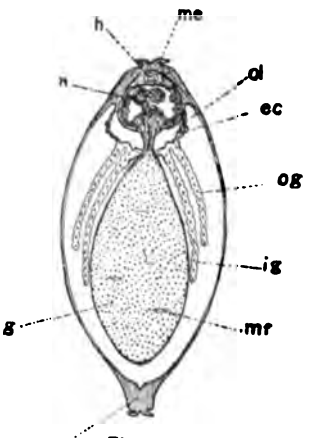


Fig.27

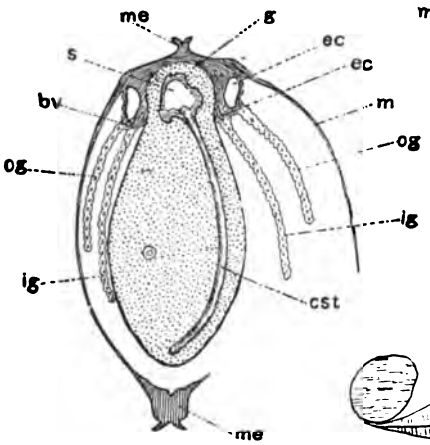


Fig.26

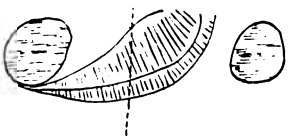


Fig.28

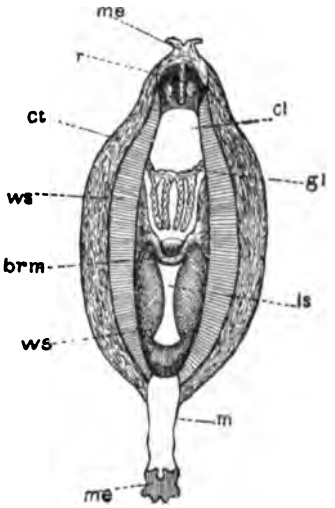


Fig.29

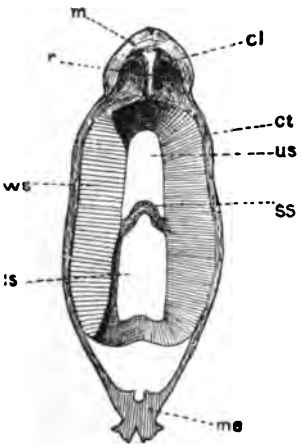
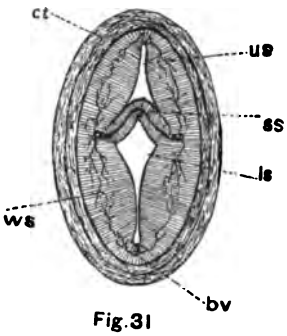


Fig.30



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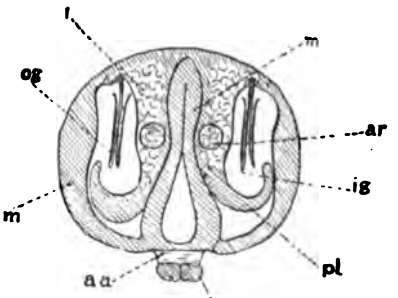

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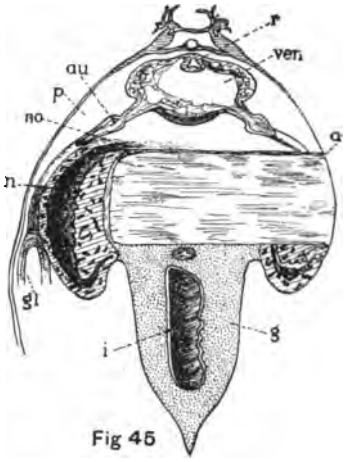

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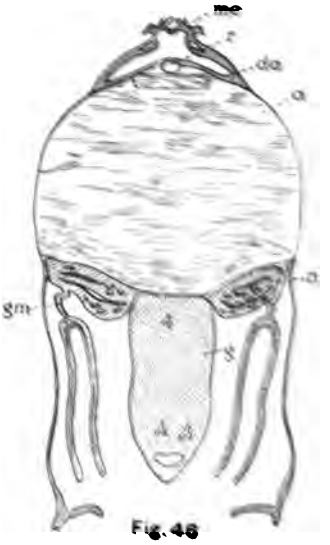

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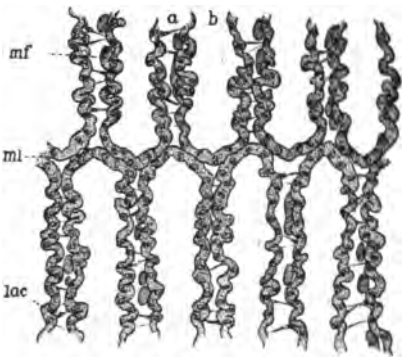

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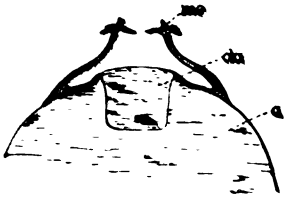

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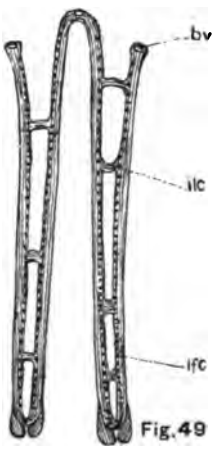
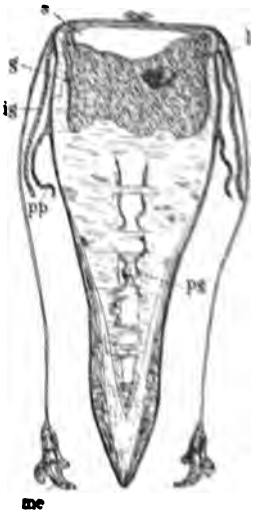


Fig.49

Fig. 50



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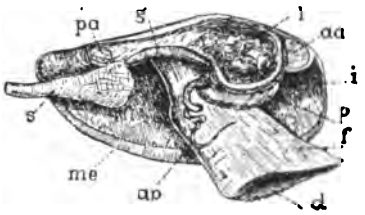

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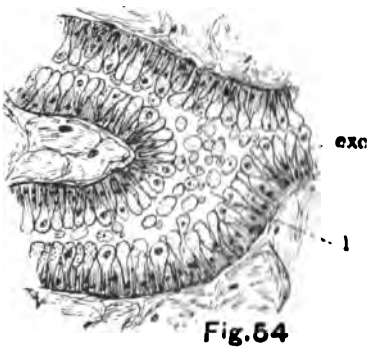

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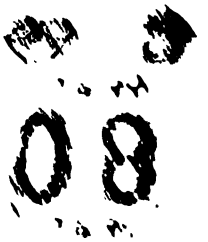
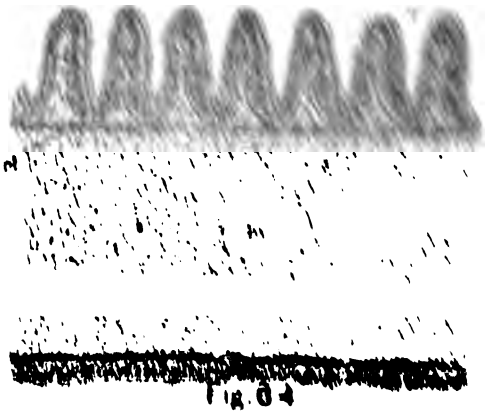


Fig.62

Fig.63



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Kellogg del.

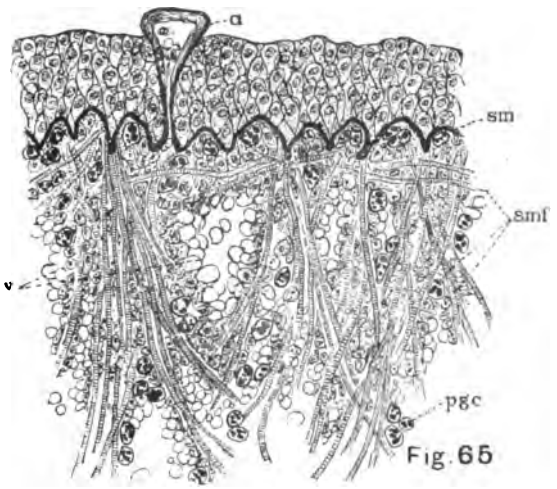


Fig. 65

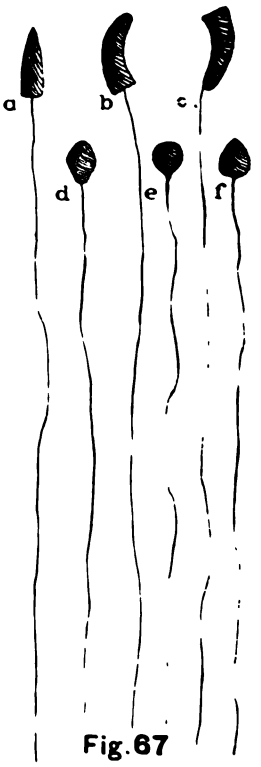


Fig. 67

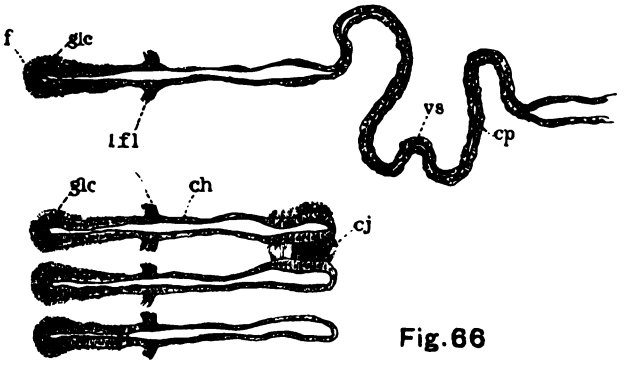


Fig. 66

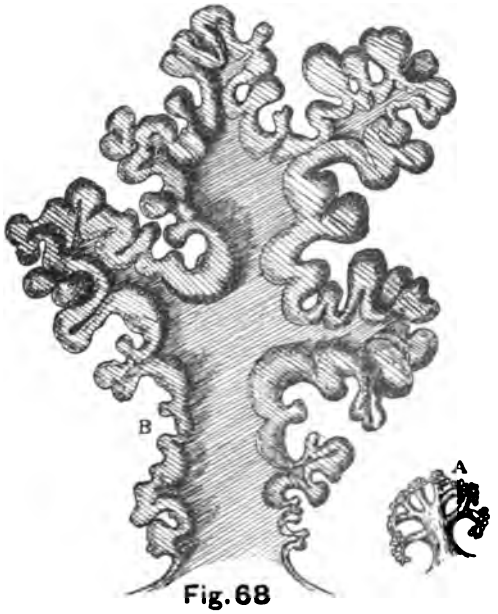


Fig. 68

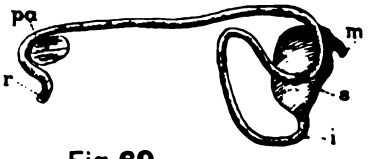
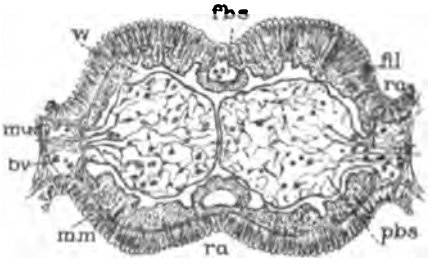


Fig. 69



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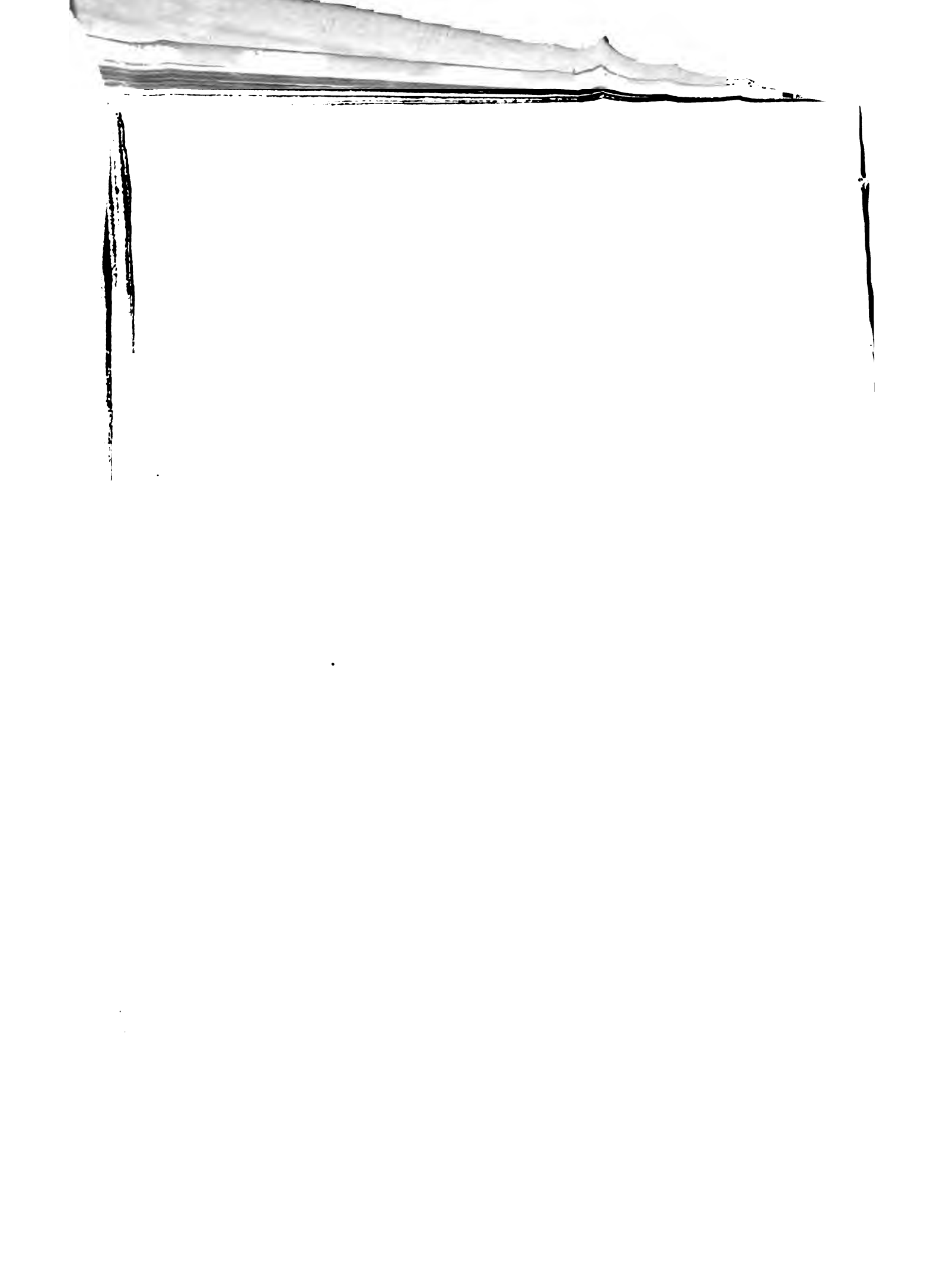


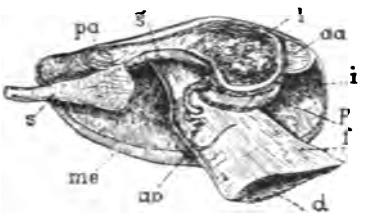
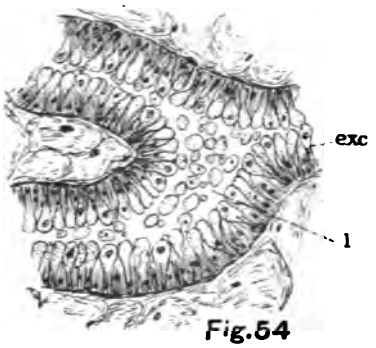


Fig.52

Fig. 53



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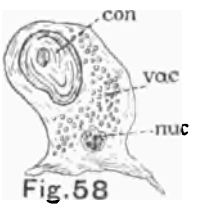

Fig.58

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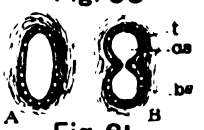

Fig.61

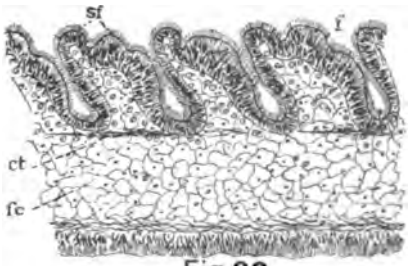

Fig.62

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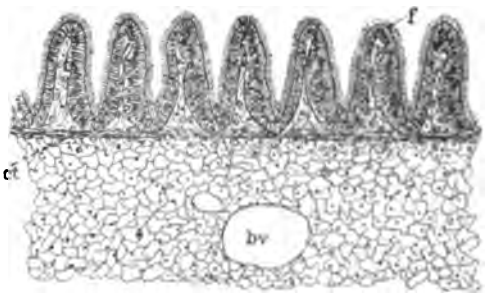

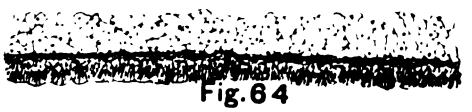
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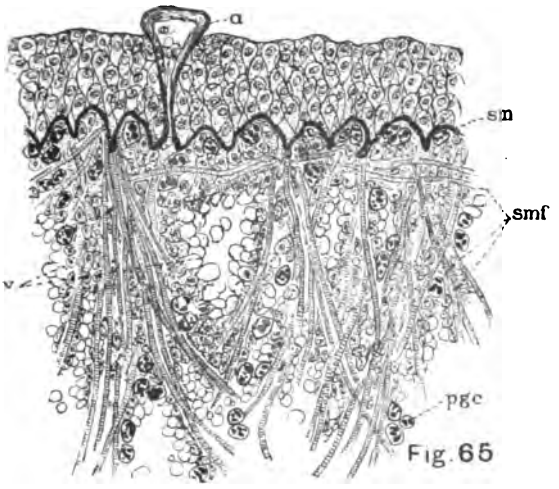


Fig. 65

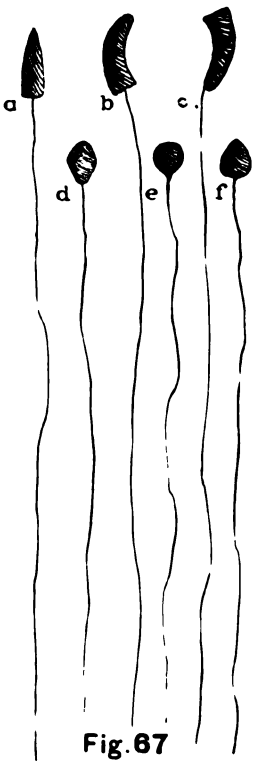
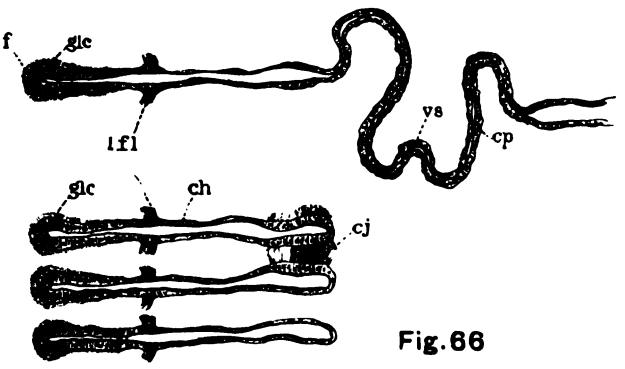


Fig. 67



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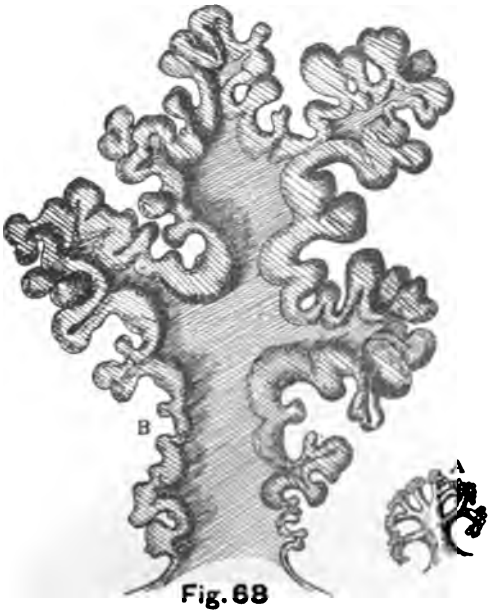

Fig. 68

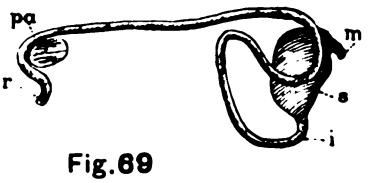

Fig. 69

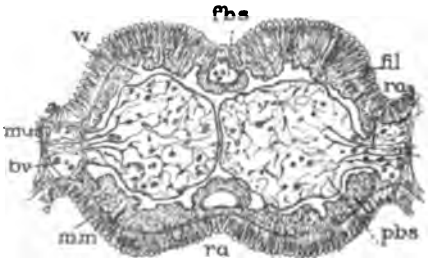

Fig. 70

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Fig.77

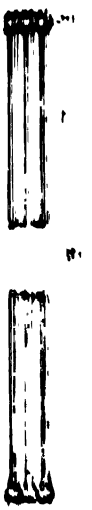
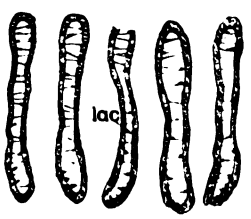


Fig.78

Fig.79



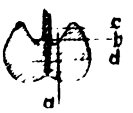


Fig.81

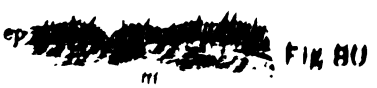


Fig.80

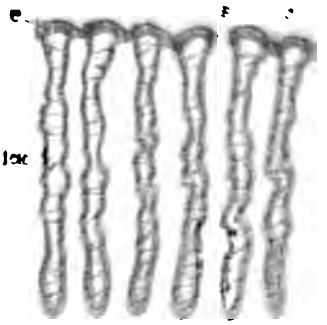


Fig.82

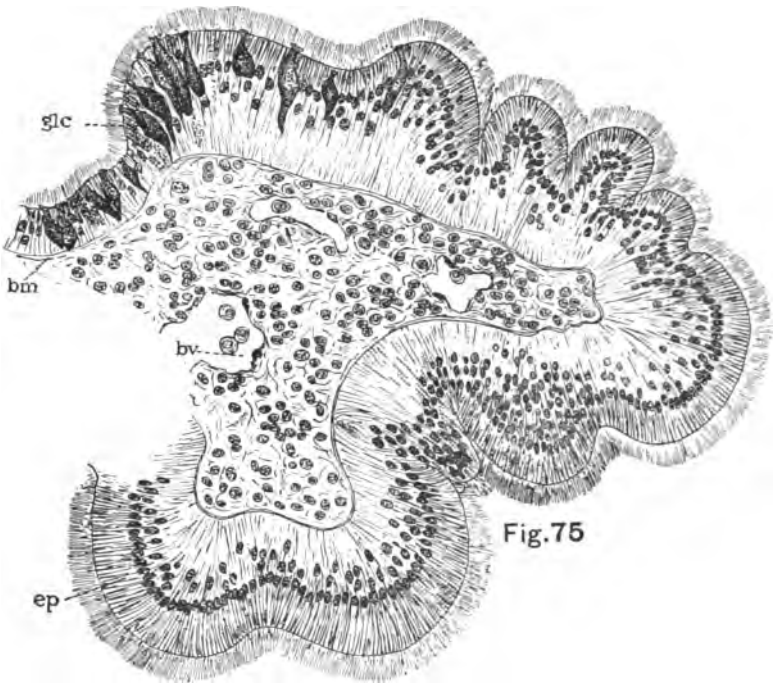


Fig.75

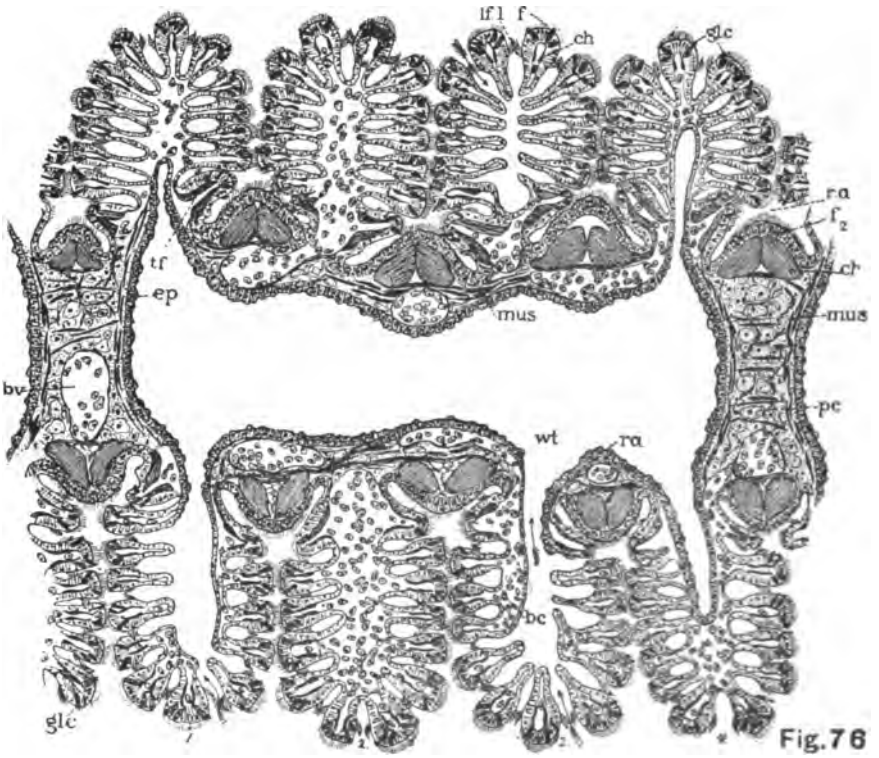


Fig.76

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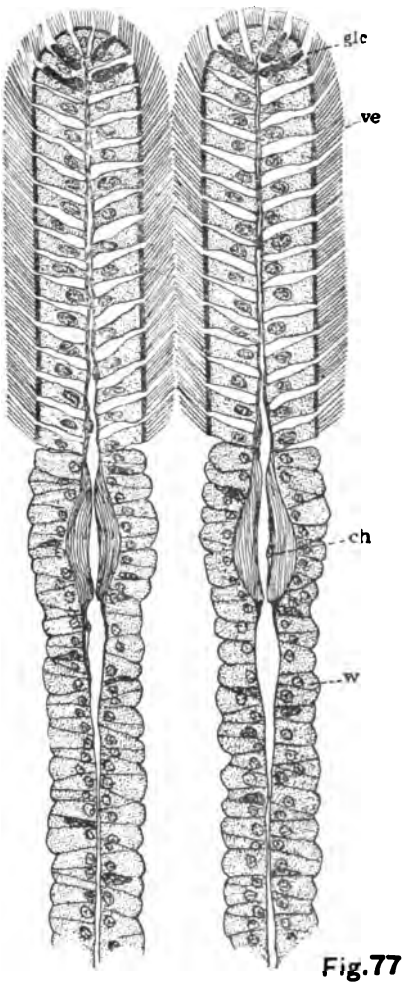
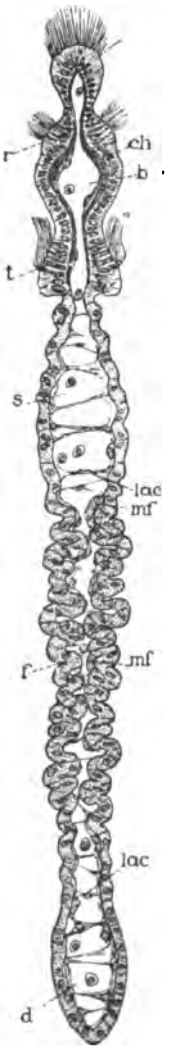


Fig.77

Fig.78



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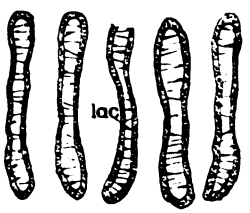


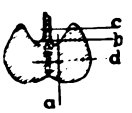


Fig.81

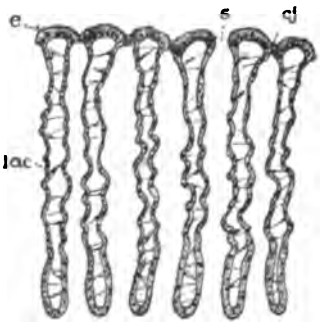
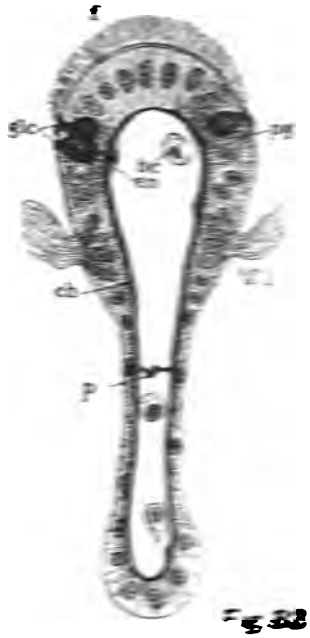


Fig.80

Fig.82

Kellogg del.



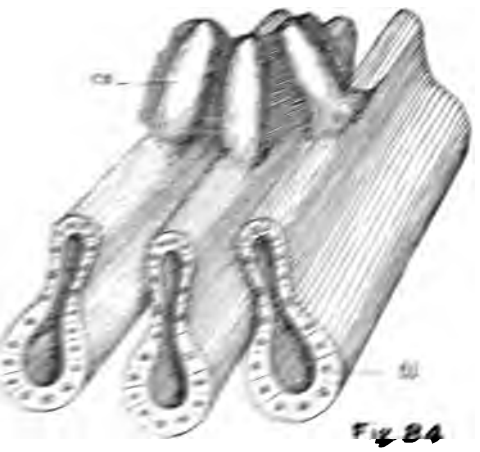
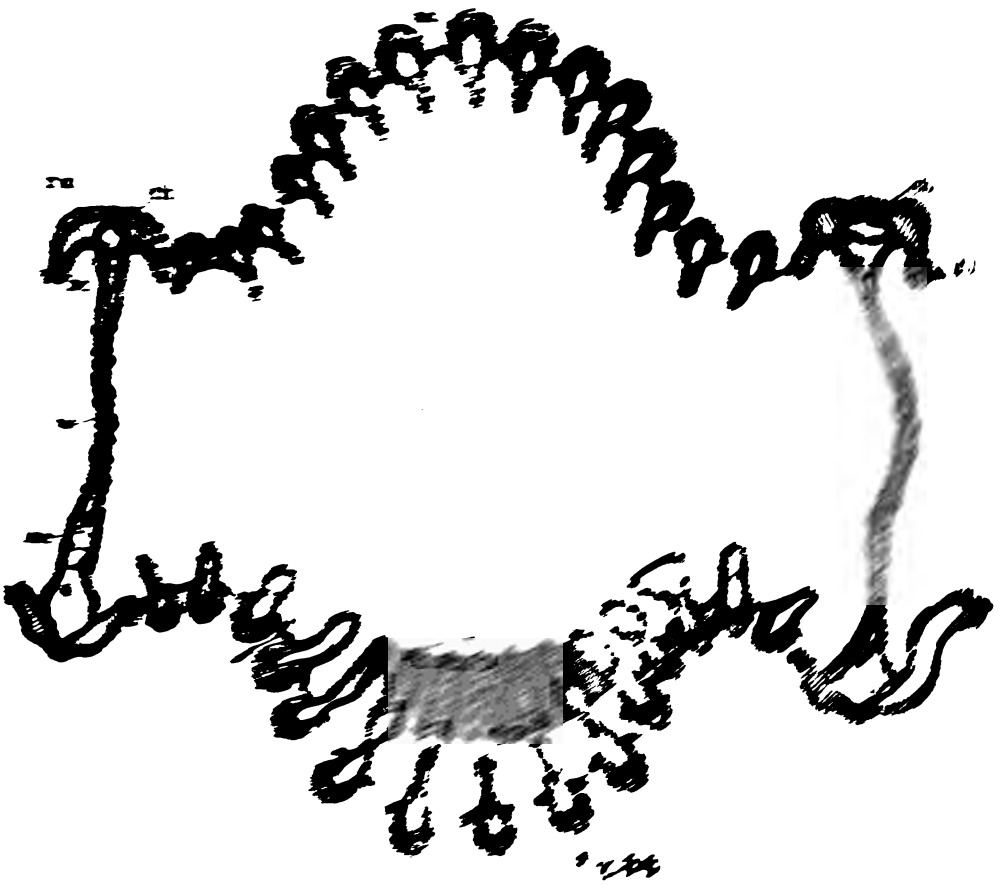


Fig 84



UNIVERSITY OF MICHIGAN

INDEX.

1. OBSERVATIONS ON THE AQUARIA AT CENTRAL STATION.

Page.

Alum used in filtering water 8
Bolecosoma olmstedi 9
Chromatophagus parasiticus 6, 7
Construction, system of 2, 3
Darters, spawning habits of 9–11
Filtering, methods of 8, 9
Fish infested with fungus 5, 6
Fish infested with parasites 6, 7
Fish transferred from fresh to salt water 5, 6
Fresh-water aquaria at Central Station 7–9
Gambusia patruelis, spawning in aquarium 12
Gasterosteus aculeatus 5
Habits of fishes in the aquaria 9–12
Hoffmann, R. S 4
Holothurian, peculiar habit of ..... [illegible]
Horse-shoe crab eggs, hatching [illegible]
Howell, E. S. ..... [illegible]
Lloyd, W. A
Marine aquaria at Central Station
McDonald, Marshall
Rocrus americanus
Ryder, Prof. John A
Sea-cucumber, peculiar habit of
Sea water, artificial
Smith, Dr. Hugh M
Top-minnows, spawning in [illegible]
Yellow perch (Perca flavescens), spawning in aquaria [illegible]

2. FISHING VESSELS AND BOATS OF THE PACIFIC COAST.

Alaskan schooners 16
Aleutian bidarkas 27, 30
Barkentine Jane Falkenburg 34
Barkentine Tremont 34
Bark Mary and Helen 13
Bean, Dr. T. H. 39
Bidarka or kaiak of Alaska 24, 26
Bidarrah, dimensions of 33
Bidarrah or oomiak 31–34
Brown, J. T., remarks on first steam whaler 14
Burling, William 39
Canoes of Kadiak 26
Chinese fishing canoe 47
Chinese fishing craft 46, 48
Chinese fishing junks 46, 47
Chinese fishing skiffs 47, 48
Cod vessels 34
Cod and halibut fleets 34, 35
Dimensions of Alaskan dugouts 23, 24
Dimensions of Aleutian bidarkas 29, 30
Dimensions of Columbia River salmon boat 39
Dimensions of fishing feluccs 43, 44
Dimensions of modern steam whalers 18
Dimensions of steam fishing schooners 35
Dories and sharpies 41, 42
Dugout canoes of Alaska 21, 23
Dugout canoes of Washington 19, 21
Elliott, Henry W 21, 22, 28, 44
Engines of steam whalers 18
First steam whaler 13
Fishing feluccs 41, 44
Fur-seal and sea-otter vessels and boats 18, 44
Goss, Sawyer & Packard ..... [illegible]
Griffin, J. J ..... [illegible]
Hall, Henry
Harvey, Rev. M ..... [illegible]
Higgins & Gifford ..... [illegible]
Hume, George and [illegible] ..... [illegible]
Jacobs, Capt. Nicholas ..... [illegible]
Kaiak of Point Barrow ..... [illegible]
Kaiak or [illegible] ..... [illegible]
Last of Alaskan salmon vessels ..... [illegible]
Makah canoe ..... [illegible]
Market fleet ..... [illegible]
[illegible] ..... [illegible]
Oyster harvest ..... [illegible]
Oyster sloops ..... [illegible]
Oyster vessels and boats ..... [illegible]
Pierce, [illegible] ..... [illegible]
Pilot's Report, [illegible] ..... [illegible]
Salmon fleet of Alaska ..... [illegible]
Salmon [illegible] ..... [illegible]
Schooners, [illegible] ..... [illegible]
San Pedro [illegible] ..... [illegible]
Steamers, [illegible] ..... [illegible]
Steam [illegible] ..... [illegible]
Steam fleet, Bering Sea ..... [illegible]
Steam fleet, [illegible] ..... [illegible]
Steam fleet, Northern ..... [illegible]
Steamers, [illegible] ..... [illegible]

UNIVERSITY OF MICHIGAN

4. NOTES ON FISHES FROM THE LOWER POTOMAC RIVER

Alewife 64
Baird, Spencer F 64, 67
Barb 72
Bean, Tarleton H 63, 67
Bluefish 71
Bull-minnow 65
Croaker 72
Crocus 72
Eel 69
Ellwife 64
Flounder 72
Garfish 69
Grumbler 72
Harvest-fish 71
Jordan, Prof. D. S 66, 68
Kingfish 72
Mayfish 65
Menhaden 64
Oldwife 64
Plaice 72
Pumpkin-seed 71
Rainwater-fish 68
Robin-perch 71
Rock 71
Rockfish 71
Sheepshead 71, 72
Sheepshead minnow 64
Short-minnow 64
Silversides 69, 70
Species referred to, scientific names—
Anguilla anguilla 69
Archosargus probatocephalus 71, 72
Batrachus tau 72
Brevoortia tyrannus 64
Cynoscion maculatum 72
Cyprinodon variegatus 64
Species referred to, scientific names—Continued.
Fundulus diaphanus 66, 68, 69
Fundulus heteroclitus 66, 68, 69
Fundulus majalis 66, 69
Gambusia patruelis 66, 68, 69
Hydrargyra Lacie 67
Leiostomus xanthurus 72
Lepomis gibbosus 70
Lucania parva 68
Menidia beryllina 66, 68, 70
Menidia notata 68, 69
Menticirrus nebulosus 72
Micropogon undulatus 72
Paralichthys dentatus 66, 72
Pomatomus saltatrix 71
Roccus lineatus 71
Scomberomorus maculatus 71
Stromateus alepidotus 71
Tylosurus marinus 69
Zygonectes luciæ 66, 67, 68
Spot 72
Spanish mackerel 71
Spotted weakfish 72
Spring minnow 68
Striped bass 71
Summer flounder 72
Sunfish 71
Tailor 71
Toadfish 72
Tobacco-box 71
Top-minnow 69
Trout 72
Uhler, P. L 72
Variegated minnow 64
Whiting 72

5.—FISHERIES OF THE NEW ENGLAND STATES.

Alewives, use of, as bait 145
Artificial propagation, results of 146
Bait fishery of Massachusetts 144, 145
Bait fishery of Maine 109
Canning industry of Maine 115, 118
Cod, haddock, hake, etc., fishery of Maine 109
Cod, results of propagation of 146
Common and scientific names of fishes, etc 75–76
Connecticut, fisheries of 165–176
Crustacean and reptilian fisheries, value of 81
Fishing-grounds 149, 152
Fishing vessels of New England 79–81
Fish trades of Boston and Gloucester 147–149
Frozen-herring trade of New England 91–93
Game fish, scarcity in pound nets 145
General fisheries, value of 81
General remarks and statistics 73–96
Halibut fishery, explanation of term 75
Herring fishery of Maine 108–109
Herring, use of, as bait 145
Horse-mackerel, utilization of 82
Lobster-canning industry of Maine 118
Lobster fishery of Maine 108
Mackerel fishery, explanation of term 75
Maine, fisheries of 96–119
Mammalian fisheries, value of 81
Market fishery, explanation of term 75
Massachusetts, fisheries of 134, 166
Menhaden fishery of New England 80, 81
Menhaden fishery, value of 81
Menhaden industry of Connecticut 170
Menhaden industry of Maine 110
Menhaden industry of Rhode Island 164
Menhaden, use of, as bait 146
Names of fishes, etc., common and scientific 75, 76
Nationalities of New England fishermen 76
New Hampshire, fisheries of 120, 123
Oyster and other mollusean fisheries, value of 81
Pound net, weir and trap fisheries, development of 82, 108
Rhode Island, fisheries of 164, 164
Salmon fishery of Maine 110
Sardine industry of Maine 115, 118
Shad fishery of Maine 110
Shore fisheries of Connecticut 171, 176
Shore fisheries of Maine 104, 114
Shore fisheries of Massachusetts 136, 146
Shore fisheries of New Hampshire 123
Shore fisheries of Rhode Island 161, 164
Shore fishery, explanation of term 75
Shore industries of Connecticut 176
Shore industries of Maine 116, 119
Shore industries of Massachusetts 147

5. FISHERIES OF THE NEW ENGLAND STATES—Continued.

Page.

Shore industries of Rhode Island 164
Smelt fishery of Maine 109
Smoked-herring industry of Maine 118–119
Soft-clam fishery of Maine 109
Squid, use of, as bait 144–145
Squid, utilization of 82

Tabular statements:

1. Number of persons employed in New England fisheries in 1889 77
2. Apparatus employed and capital invested in New England fisheries in 1889 77
3. Showing, by species, the yield of fisheries of New England States in 1889 ..... 78, 79
4. Showing number and nationality of persons employed in New England vessel fisheries in 1889 .. 79
5. Showing by States and rigs the number and tonnage of vessels employed in New England fisheries in 1889 81
6. Values of various coast fisheries of New England States in 1889 81
7. Quantities, values, and percentages of fishery products taken in each kind of apparatus in New England States in 1889 83
8. Showing by States the actual and relative importance of the vessel and shore fisheries of New England in 1889 84
9. Relative importance of each of the vessel fisheries of the New England States in 1889 85
10. Certain averages and percentages for vessels employed in New England fisheries in 1889 87
11. Certain averages and percentages for the shore fisheries of the New England States in 1889 87
12. Showing for each of fifteen important species the percentage of value in each New England State to the total value of the catch in New England. 88
13. Comparative table showing number of persons employed in New England fisheries in 1880 and 1889. 89
14. Comparative table showing number and value of vessels, boats, etc., employed in New England fisheries in 1880 and 1889 89
15. Comparative table showing values of fisheries of New England States in 1880 and 1889 90
16. Extent of menhaden industry of New England States in 1889 91
17. Extent of frozen-herring trade of New England States in 1889 93
18. Number and value of frozen herring landed in New England States by Canadian vessels in 1889 93
19. Persons employed in the fisheries of Maine 94
20. Apparatus and capital employed in Maine fisheries. 94
21. Products of Maine fisheries 95
22. Showing by counties the number and nationality of men employed in vessel fisheries of Maine in 1889 96
23. Showing by counties the number and value of vessels and apparatus employed in vessel fisheries of Maine in 1889 97
24. Showing by counties the yield of vessel fisheries of Maine in 1889 97–98
25. Showing by counties certain average figures for vessels employed in fisheries of Maine in 1889 .. 99
26. Showing by counties the percentage of value of each species or product taken in the vessel fisheries of Maine in 1889 99

Page.

Tabular statements—Continued.

27. Summary by customs districts of the vessel fisheries of Maine in 1889 100
28. Showing by species and customs districts the yield of the vessel fisheries of Maine in 1889 100–101
29. Showing by customs districts the average tonnage, value, crew, and stock of vessels employed in the fisheries of Maine in 1889 102
30. Showing by apparatus and species the yield of the vessel fisheries of Maine in 1889, exclusive of the molluscan and crustacean fisheries 102
31. Number of vessels engaged in each fishery in Maine in 1889, together with their tonnage, value, and number of crew 103
32. Showing by fishing-grounds and apparatus, the catch of the mackerel fleet of Maine in 1889 103
33. Showing by fisheries and species the yield of the vessel fisheries of Maine in 1889 104
34. Showing by counties the number of persons engaged in the shore fisheries of Maine in 1889 106
35. Showing by counties the apparatus employed in the shore fisheries of Maine in 1889 106
36. Showing by counties and species the yield of the shore fisheries of Maine in 1889 107
37. Showing by counties and apparatus the yield of the shore fisheries of Maine in 1889 111–113
38. Relative quantity and value of yield in each principal form of apparatus of capture employed in the shore fisheries of Maine in 1889 113
39. Showing by counties certain averages and percentages of the shore fisheries of Maine in 1889. 114
40. Showing by counties the percentage of the value of each species to the total yield of the shore fisheries of Maine in 1889 114
41. Showing by counties the products of the canning industry of Maine in 1889 115–116
42. Summary by counties of the canning industry of Maine in 1889 116
43. Classification of employés of sardine canneries in Washington and Hancock counties, Maine, in 1889, with statement of weekly and annual wages 117
44. Number and value of supply boats employed in the sardine industry of Washington and Hancock counties, Maine, in 1889 118
45. Extent of the lobster-canning industry of Maine in 1889 118
46. Extent of the smoked-herring industry of Maine in 1889 118
47. Quantities of smoked herring prepared by fishermen and sardine-canners of Maine in 1889 119
48. Comparative table showing quantity of herring smoked in Maine in 1880, 1887, 1888, and 1889 ... 119
49. Extent of menhaden industry of Maine 119
50. Persons employed in New Hampshire fisheries ... 120
51. Apparatus and capital in New Hampshire fisheries 120
52. Products of New Hampshire fisheries 120
53. Number of vessels engaged in each fishery in New Hampshire in 1889, with tonnage, value, and number of crew 121
54. Showing by fisheries and species the yield of the vessel fisheries of New Hampshire in 1889 121
55. Showing by species the yield of the vessel fisheries of New Hampshire in 1889 122

UNIVERSITY OF MICHIGAN

5. FISHERIES OF THE NEW ENGLAND STATES—Continued.

Page.

Tabular statements—Continued.

56. Showing by apparatus and species the yield of the vessel fisheries of New Hampshire in 1889, exclusive of the lobster fisheries 122
57. Showing by species the yield of the shore fisheries of New Hampshire in 1889 123
58. Showing by apparatus and species the yield of the shore fisheries of New Hampshire in 1889 123
59. Persons employed in Massachusetts fisheries 124
60. Apparatus and capital employed in Massachusetts fisheries 124
61. Products of Massachusetts fisheries 125
62. Showing by counties the number and nationality of men employed in the vessel fisheries of Massachusetts in 1889 127
63. Showing by counties the number and value of vessels and apparatus employed in the vessel fisheries of Massachusetts in 1889 127
64. Showing by counties and species the yield of the vessel fisheries of Massachusetts in 1889 128-129
65. Showing by counties certain average figures for the vessels employed in the fisheries of Massachusetts in 1889 129
66. Showing by counties the percentage of value of each species or product taken in the vessel fisheries of Massachusetts in 1889 130
67. Showing by species and customs districts the yield of the vessel fisheries of Massachusetts in 1889 130-131
68. Summary by customs districts of the vessel fisheries of Massachusetts in 1889 132
69. Showing by customs districts the average tonnage, value, crew, and stock of vessels employed in the fisheries of Massachusetts in 1889 132
70. Showing by apparatus and species the yield of the vessel fisheries of Massachusetts in 1889, exclusive of molluscan, crustacean, and mammalian fisheries 133
71. Number of vessels engaged in each fishery in Massachusetts in 1889, with tonnage, value, and number of crew 133
72. Showing by fisheries and species the yield of the vessel fisheries of Massachusetts in 1889 134
73. Showing by fishing-grounds the catch of the mackerel (by apparatus), the bank cod, the Grand and Western bank fresh halibut, and the Iceland halibut fleets of Massachusetts in 1889 135
74. Showing by counties the number of men employed in the shore fisheries of Massachusetts in 1889.. 137
75. Showing by counties the apparatus employed in the shore fisheries of Massachusetts in 1889..... 137
76. Showing by counties and species the yield of the shore fisheries of Massachusetts in 1889 137-138
77. Showing by counties and apparatus the yield of the shore fisheries of Massachusetts in 1889..138-142
78. Relative quantity and value of yield in each principal form of apparatus of capture employed in shore fisheries of Massachusetts in 1889 142
79. Showing by counties certain averages and percentages of shore fisheries of Massachusetts in 1889 143
80. Showing by counties the percentage of value of each species to the total yield of the shore fisheries of Massachusetts in 1889..... 145

Page.

Tabular statements—Continued.

81. Showing by counties and apparatus the quantities of fish and squid taken in the shore fisheries of Massachusetts in 1889 and sold for bait..... 145
82. Showing by counties and species the quantities of fish and squid taken in the shore fisheries of Massachusetts in 1889 and sold for bait..... 145
83. Showing by apparatus and species the quantities of fish and squid taken in the shore fisheries of Massachusetts in 1889 and sold for bait 145
84. Extent of wholesale fish trades and related industries of Gloucester, Mass., in 1889 148
85. Extent of wholesale fish trades of Boston, Mass., in 1889..... 149
86. Showing by fishing-grounds the quantities of fish landed at Gloucester, Mass., in 1889, by New England fishing vessels 150
87. Showing by fishing-grounds the quantities of fresh ground-fish landed at Boston, Mass., in 1889, by New England fishing vessels 153
88. Showing by fishing-grounds and months the quantities of fresh and salt mackerel landed at Boston, Mass., in 1889, by New England fishing vessels 154
89. Persons employed in Rhode Island fisheries 154
90. Apparatus and capital employed in Rhode Island fisheries..... 154
91. Products of Rhode Island fisheries..... 155
92. Showing by counties the number and nationality of persons employed in the vessel fisheries of Rhode Island in 1889..... 156
93. Showing by counties the number tonnage value and outfits of vessels employed in the vessel fisheries of Rhode Island in 1889 156
94. Showing by counties the yield of vessel fisheries of Rhode Island in 1889 156
95. Showing by counties certain average figures for vessels employed in the fisheries of Rhode Island in 1889..... 157
96. Summary by customs districts of the vessel fisheries of Rhode Island in 1889..... 157
97. Showing by species and customs districts the yield of vessel fisheries of Rhode Island in 1889 157
98. Showing by customs districts the average tonnage value crew and stock of vessels employed in the fisheries of Rhode Island in 1889 158
99. Showing by apparatus and species the yield of the vessel fisheries of Rhode Island in 1889, exclusive of the molluscan and crustacean fisheries 158
100. Number of vessels engaged in each fishery in Rhode Island in 1889 with tonnage value and number of crew 159
101. Showing by fisheries and species the yield of the vessel fisheries of Rhode Island in 1889 159
102. Showing by counties the number of persons engaged in the shore fisheries of Rhode Island in 1889 160
103. Showing by counties the apparatus employed in the shore fisheries of Rhode Island in 1889 161
104. Showing by counties and species the yield of the shore fisheries of Rhode Island in 1889 161
105. Showing by counties and apparatus the yield of the shore fisheries of Rhode Island in 1889... 162

5. FISHERIES OF THE NEW ENGLAND STATES—Continued.

Page.

Tabular statements—Continued.
106. Relative quantity and value of yield in each principal form of apparatus of capture employed in the shore fisheries of Rhode Island in 1889..... 162
107. Showing by counties certain averages and percentages of the shore fisheries of Rhode Island in 1889 163
108. Showing by counties the percentage of the value of each species to the total yield of the shore fisheries of Rhode Island in 1889..... 164
109. Extent of menhaden industry of Rhode Island.... 164
110. Persons employed in Connecticut fisheries..... 165
111. Apparatus and capital employed in Connecticut.. 165
112. Products of Connecticut fisheries..... 166
113. Showing by counties the number and nationality of persons engaged in the vessel fisheries of Connecticut in 1889..... 167
114. Showing by counties the number, value, and net tonnage of vessels and the quantity and value of apparatus of capture employed in the vessel fisheries of Connecticut in 1889 167
115. Showing by counties the yield of the vessel fisheries of Connecticut in 1889..... 168
116. Showing by counties certain average figures for vessels employed in the fisheries of Connecticut in 1889..... 168
117. Summary by customs districts of the vessel fisheries of Connecticut in 1889 168
118. Showing by species and customs districts the yield of the vessel fisheries of Connecticut in 1889.... 169
119. Showing by customs districts the average tonnage, value, crew, and stock of vessels employed in the fisheries of Connecticut in 1889..... 169
120. Showing by apparatus and species the yield of the vessel fisheries of Connecticut in 1889, exclusive of molluscan, crustacean, and mammalian fisheries 170

Page.

Tabular statements—Continued.
121. Number of vessels engaged in each fishery in Connecticut in 1889, with tonnage, value, and number of crew 170
122. Showing by fisheries and species the yield of the vessel fisheries of Connecticut in 1889..... 171
123. Showing by counties the number of persons engaged in the shore fisheries of Connecticut in 1889..... 172
124. Showing by counties the apparatus employed in the shore fisheries of Connecticut in 1889..... 172
125. Showing by counties and species the yield of the shore fisheries of Connecticut in 1889 172
126. Showing by counties and apparatus the yield of the shore fisheries of Connecticut in 1889....173–174
127. Relative quantity and value of yield in each principal form of apparatus of capture employed in the shore fisheries of Connecticut in 1889..... 174
128. Showing by counties certain averages and percentages of the shore fisheries of Connecticut in 1889 175
129. Showing by counties the percentage of value of each species to total yield of shore fisheries of Connecticut in 1889 175
130. Extent of menhaden industry of Connecticut in 1889 176

Vessel fisheries, relative importance of..... 85
Vessel fisheries of Connecticut.....166–171
Vessel fisheries of Maine.....95–104
Vessel fisheries of Massachusetts.....126–135
Vessel fisheries of New Hampshire 121–122
Vessel fisheries of Rhode Island.....155–159
Washington treaty, effects of abrogation.....83, 108, 109
Weights of products, explanation of system 74
Whiting, utilization of..... 82

6. THE FISHERIES OF LAKE ONTARIO.

Alewife.....187–192
Atlantic salmon.....195–202
Bait fishes.....210–211
Calico bass 209
Canadian import trade.....183–185
Cape Vincent customs district 184
Commercial fishes, notes on.....185–209
Deficient food, effect on alewives.....191–192
Dominion of Canada, whitefish planted by 205
Fishes referred to, common names:
Alewife.....187–192, 211, 214
Atlantic salmon.....195–202, 214
Bait fishes 210–211
Black bass, large-mouthed 214
small-mouthed..... 215
Bloater..... 207
Bloater whitefish..... 207
Blue pike..... 208
Blunt-nosed minnow 211
Branch herring..... 214
Bullhead 213
Burbot..... 215
Calico bass 209, 214
Carp, leather 213
Carp mullet 213
Fishes referred to, common names—Continued.
Chub.....211, 212
Cisco.....206, 214
Ciscoette..... 207
Cusk, fresh-water..... 215
Dace 211
Dogfish 211, 213
Dory 215
Drum, fresh-water 215
Fallfish 211
Fresh-water cusk..... 215
drum..... 215
Gaspereau 187
Gizzard 214
Grass bass 209
Herring, branch..... 214
lake 206, 214
Horned dace.....211, 214
Hornyhead..... 211
Hoy's whitefish 206, 207, 214
Johnny darter..... 211
Lake herring.....206, 214
moon-eye..... 214
trout 202–203, 214
Lawyer..... 215

UNIVERSITY OF MICHIGAN

6. THE FISHERIES OF LAKE ONTARIO Continued.

Page.

Fishes referred to, common names—Continued.
- Leather carp 213
- Ling 215
- Little shad 187
- Long-jaw 207, 214
- Mad pike 209
- Manhaden 187
- Menhaden 187
- Menominee whitefish 206, 207, 214
- Minnows 210, 211
- Mongrel whitefish 206, 207
- Moon-eye 187, 206, 207, 214
- Mudfish 213
- Mud-minnow 211
- Mud-shad 214
- Mullet 210, 213
- Muskellunge 214
- Ontario whitefish 207
- Oswego bass 214
- Perch, yellow 215
- Pickerel 208, 214
- Pike 214
  - blue 208
  - perches 208–209, 215
  - sand 215
  - wall-eyed 208, 215
  - yellow 208
- Redfin 211
- Roach 211
- Rock bass 214
- Rock sturgeon 185
- Round whitefish 206, 207, 214
- Salmon 195–202, 214
- Salmon trout 202–203, 214
- Sand pike 215
- Sauger 209, 215
- Sawbelly 187
- Shad 187, 193–195, 211, 214
- Sheepshead 215
- Shiner 211
  - common 211
- Silver-fin 211
- Silver whitefish 207
- Siscowet 207
- Skipjack 214
- Spawn-eater 211
- Stone-lugger 210
- Stone-roller 210
- Strawberry bass 209, 214
- Sturgeon 185–187, 213
- Sucker 211
- Sucker, brook 213
  - common 210, 213
- Tullibee 206, 207, 214
- Wall-eyed pike 208, 215
- Whitefish, bloater 207
  - common 204–206, 214
  - Hoy's 206, 207, 214
  - Menominee 206, 207, 214
  - mongrel 206, 207, 214
  - Ontario 207
  - round 206, 207, 214
  - silver 207
- Whitefishes, lesser 206–207

Page.

Fishes referred to, common names—Continued.
- Yellow perch 215
  - pike 208

Fishes referred to, scientific names:
- Acipenser rubicundus 185, 213
- Ambloplites rupestris 214
- Ameiurus vulgaris 213
  - nebulosus 213
- Amia calva 213
- Aplodinotus grunniens 213
- Campostoma anomalum 210
- Catostomus teres 210, 213
- Clupea chrysochloris 214
  - pseudoharengus 187, 211, 214
  - sapidissima 193, 214
- Coregonus artedi 206, 207, 214
  - clupeiformis 204, 214
  - hoyi 206, 207, 214
  - quadrilateralis 206, 214
  - tullibee 206
- Cyprinus carpio 213
- Dorosoma cepedianum 214
- Esox lucius 194, 214
  - nobilior 214
- Etheostoma nigrum 211
- Hiodon tergisus 214
- Hybopsis kentuckiensis 211
- Lota maculosa 210
- Micropterus dolomieu 210
  - salmoides 214
- Moxostoma aureum 213
- Notropis heterodon 211
  - hudsonius 211
  - megalops 211
  - whipplei 211
- Perca flavescens 210
- Pimephales notatus 211
- Pomoxis sparoides 209, 214
- Salmo salar 195, 214
- Salvelinus namaycush 202, 214
- Semotilus atromaculatus 211, 214
  - bullaris 211
- Stizostedion canadense 209, 210
  - vitreum 209, 210
  - vitreum, var salmoneum 209
- Umbra pygmæa 211
- Fungous disease of alewives 191
- Genesee customs district 164
- How the fisheries of Lake Ontario may be improved 212, 213
- Lake Ontario, character of bottom 179
  - depth 178, 179
  - elevation 178
  - size 178
- Lake trout 202, 203
- Michigan fish commission, station of, at Detroit 203
  - sturgeon hatching by 187
- Mortality of alewives 190, 192
- New York fish commission, report quoted 189, 200
  - salmon trout planted by 201
  - shad planted by 214
  - whitefish planted by 206, 212
- Notes on accompanying plates 213, 215
- Important commercial fishes 195, 202

6. THE FISHERIES OF LAKE ONTARIO Continued.

Page.

Oath, form of, taken by importers 183
Oswego customs district 184
Persons referred to or quoted:
Ainsworth, W 194
Baird, Prof. Spencer F., on salmon 198, 199
shad 193
Bean, Dr. T. H., on alewife 188
Collins, Capt. J. W 177
Dolley, Prof. Charles S., on alewife 192
Douglass, Earl S., on salmon 198
Doyle, Edward P 203
Edmunds, Dr. M. C., on salmon 198, 199, 200
Gilbert, Dr. Charles H 211
Green, Seth, on alewife 188
salmon 198, 200
shad fry planted by 193
Green, Seth, jr., on alewife 188
Henshall, Dr. J. A., on black bass 215
Horton, E. B., on salmon 198
Ingersoll, B. E., on salmon 196, 201
salmon trout 203
lake trout 203
Jordan, Prof. D. S., on Hoy's whitefish 207
Kirtland, Prof. J. P., on strawberry bass 209
Learned, Charles, on salmon 197
McDonald, Hon. Marshall, on alewife 191
salmon 200, 202
Lake Ontario fisheries 213
Matheson, H. L 194
Milner, J. W., on sturgeon 186
Nelson, W. E., on salmon 197
Norris, Thaddeus, on salmon 198
Ryder, Prof. John A., on sturgeon 186

Page.

Persons referred to or quoted—Continued.
Strowger, Charles H., on alewife 189, 192
ling 215
Wilmot, S., on alewife 192
Wilson, John S., on salmon 197
Physical characteristics of Lake Ontario 178–179
Pike perches 208–209
Prefatory note 177–178
Present and past condition of Lake Ontario fisheries 179–183
Rochester Post-Express quoted 191, 192
Salmon trout 202–203
Shad 193–195
Statistics of Lake Ontario fisheries 179–183
Storms, effect of, on alewives 192
Strawberry bass 209
Sturgeon 185–187
Tabular statements:
Capital invested 180
Comparative statistics for 1880 and 1890 183
Importations from Canada 184
Persons employed 180
Products 181
Shad fry planted 193
Whitefish fry planted 205
Wholesale prices of fish 182
Tariff law, effects of 184
Temperature of water, effect of, on alewives 192
United States Fish Commission, investigation by 177
station of, at Put-in-Bay 206
sturgeon hatching by 187
whitefish planted by 205
Whitefish, common 204–206
Whitefishes, lesser 206–207

7. REPORT UPON THE FISHES OF IOWA.

Big Sioux River 246
Boyer River 248
Boynton, E. P 217
Burnett, Prof. Percy B 217
Call, R. E 217
Cedar River and tributaries 230–236
Clear Lake 237
Des Moines River and tributaries 222–225
Drainage of the Mississippi River 220–244
Drainage of the Missouri River 245–248
Gilbert, Prof. C. H 217
Iowa River 227–229
Ives, C. J 217
Jackson, W. T 217
Jordan, Prof. David S 217
Maquoketa River 240–241
Mississippi River 220–222
Missouri River 245
Nutting, C. C 217
Shaw, B. F 217, 219
Silver Lake 247
Skunk River 225–226
Soldier River 247
Species enumerated:
Acipenser rubicundus 221
Ambloplites rupestris 222, 224, 226 235, 237, 239, 246
Ameiurus melas 221, 223, 225, 228, 232, 237, 238, 240, 242 244, 247, 248
natalis 232

Species enumerated—Continued.
Ameiurus nebulosus 221, 225, 232, 238
nigricans 221
Amia calva 221, 228, 232
Ammocœtes branchialis 225, 228, 231
Anguilla chrysypa 222, 224, 229, 235
Aplodinotus grunniens 222, 236, 246
Campostoma anomalum 223, 225, 228, 233, 240, 242, 243, 244
Carpiodes velifer 221, 223, 225, 228, 232, 238, 245, 246
Catostomus nigricans 223, 225, 228, 232, 238, 240, 242, 243
teres 221, 223, 225, 228, 232, 238, 240, 242, 243, 244, 246, 248
Chænobryttus gulosus 222, 229, 235
Chrosomus erythrogaster 223, 225, 228, 2 3, 240, 242, 243
Cliola vigilax 221, 223, 226, 228, 233, 239, 244
Clupea chrysochloris 221
Cottus bairdi 242, 243
Couesius dissimilis 229
Cycleptus elongatus 221
Dorosoma cepedianum 221, 234, 239, 245, 246
Erimyzon sucetta 232
Etheostoma aspro 225, 236, 239, 236, 239, 241, 242, 246
caprodes 224, 236
cœruleum 226, 236, 239, 243
evides 236
flabellare 225, 229, 236, 237, 239, 241, 242, 244
iowæ 225, 226, 229, 236
jessiæ 225, 236, 236
microperca 236, 241

UNIVERSITY OF MICHIGAN

7. REPORT UPON THE FISHES OF IOWA—Continued.

Page.

Species enumerated—Continued.

Etheostoma nigrum .224, 226, 229, 236, 237, 239, 241, 242, 243, 244, 246, 248
pellucidum clarum 222, 224, 236, 239
phoxocephalum 222, 225, 236
shumardi 222
zonale 225, 226, 236, 241, 242, 246
Fundulus zebrinus 224, 229, 235, 237, 246, 247
Eucalia inconstans 235, 241, 242, 243, 244
Hiodon alosoides 245, 246
tergisus 234
Hybognathus nubila 228, 233, 238, 242
nuchalis 221, 223, 225, 228, 233, 238, 240, 245, 246, 247
nuchalis placita 223
Hyborhynchus notatus 245
Hyopsis dissimilis 234, 239, 242
gelidus 245
kentuckiensis 224, 226, 229, 234, 239, 241, 242, 243, 244, 246
storerianus 221, 224, 229, 234, 239, 242
Ictalurus furcatus 221
punctatus 221, 223, 225, 228, 232, 238, 245, 246
Ictiobus bubalus 221
cyprinella 221, 225, 238
sp 242
urus 221
Labidesthes sicculus 222, 224, 226, 235, 237, 239
Lepisosteus osseus 221, 223, 228, 232, 238
platystomus 221
Lepomis cyanellus 222, 224, 226, 229, 235, 239, 241, 242, 246, 247, 248
gibbosus 222, 235, 239
holbrooki 222, 235
humilis 222, 224, 226, 235, 246, 248
macrochirus 235
megalotis 222, 224, 229, 235, 241, 244, 247
pallidus 222, 224, 226, 229, 235, 237, 239, 241
Leptops olivaris 221, 232
Lota lota maculosa 222
Lucius lucius 222, 224, 226, 229, 235, 237, 239, 248
masquinongy 222, 226
vermiculatus 221, 224, 235
Micropterus dolomieu 222, 224, 226, 236, 237, 239, 241, 242
salmoides 222, 224, 226, 229, 236, 237, 239
Minytrema melanops 221, 225, 228
Morone interrupta 222
Moxostoma anisurum 223, 232
aureolum 225
duquesnei 221, 223, 225, 228, 232, 238, 240, 242, 244, 246
sp 225
Notemigonus chrysoleucus 221, 224, 226, 234, 237, 239, 241, 246, 247

Page.

Species enumerated—Continued.

Notropis amogenus 233
ardens 224, 226, 228, 234, 239, 240, 242, 244
atherinoides 229, 231, 246
cayuga 223, 226 228, 233, 239, 240, 246
deliciosus 221, 223, 226, 228, 233, 239, 240, 242, 244, 246, 248
dilectus 221, 224, 226, 229, 234, 239, 240, 242, 243, 244, 245, 246
gilberti .221, 223, 226, 228, 233, 239, 240, 242, 247, 248
heterodon 223, 226, 228, 233, 240, 242, 247
hudsonius 237, 246
jejunus 221, 234, 242
lutrensis 223, 248
megalops 224, 226, 228, 233, 239, 240, 242 243, 244, 246, 247, 248
topeka 223, 228, 233, 246, 248
whipplei 221, 223, 226, 228, 233, 239, 240, 242, 244, 246
Noturus exilis 223, 225
flavus 232, 245, 246
gyrinus 221, 223, 225, 228, 232, 246
Perca flavescens 222, 225, 229, 236, 237, 246, 247
Percopsis guttatus 246, 248
Petromyzon concolor 221, 223, 228, 231
Phenacobius mirabilis 224, 226, 229, 234, 248
Phoxinus elongatus 243
Pimephales notatus 221, 223, 226, 228, 233, 237, 238, 240, 242, 243, 244, 246, 247
promelas 223, 226, 233, 238, 240, 242 243, 244, 247, 248
Placopharynx carinatus 223
Platygobio gracilis 245
Polyodon spathula 221, 228, 231, 245
Pomoxis annularis 222, 224, 229, 235, 239
sparoides 222, 226, 229, 235, 237, 239
Rhinichthys atronasus 224, 234, 240, 242, 243, 244
cataractæ 244
Roccus chrysops 222, 246, 247
Salvelinus fontinalis 221, 235
Scaphirhynchus platyrhynchus 221, 231, 245
Semotilus atromaculatus 221, 224, 226, 234, 241, 242, 243, 247, 248
Stizostedion canadense 223, 236, 246
vitreum 222, 229, 236, 237, 246
Umbra limi 229, 235
Zygonectes dispar 236
notatus 224, 226, 229, 235, 239
Turkey River 241 242
Upper Iowa River 244
Wapsipinicon River 238–239
Yellow River 243
White, Joseph 217

8. REPORT OF AN EXAMINATION OF THE RIVERS OF KENTUCKY.

Bayou de Chien 273–274
Beaver Creek 255
Big Barren River 254
Big Creek 276
Big Sandy River 281–284
Blaine Creek 282
Bull Creek 276
Chambers, Charles O 249
Clear Creek 264
Clinton County, fishes of 267
Coon Creek 282
Cumberland River 264–266
Cutshin Creek 277
Drake Creek 254
Gilbert, Charles H 249
Goose Creek 276
Green River 255 266
Hector Creek 276

Henshall, James A
Horse Creek
Introduction
Island Creek
John Creek
Jordan, David S
Kirsch, Philip H
Left Troublesome Creek
Levisa Fork
Licking River
Little Barren River
Little Rockcastle River
Little Sandy River
Lower Cumberland River
Lower Green River
Lower Tennessee River
Mayfield Creek
McDonald, Marshall
Middle Fork
Monical, Hiram W
North Fork
Obion River
Pitman Creek
Pond Creek
Powell River
Redbird Creek
Richland Creek
Right Fork of Beaver Creek
River basins, classification of
Robinson Creek
Rockcastle River
Rolling Fork of Salt River
Rough Creek
Shelby Creek
Smoky Fork
Species enumerated in lists
Acipenser rubicundus
Ambloplites rupestris
Ameiurus natalis
nebulosus
Amia calva
Anguilla chrysypa
Aphredoderus sayanus
Apledinotus grunniens
Campostoma anomalum
Chrosomus erythrogaster
Carpiodes carpio
difformis
velifer
Catostomus nigricans
teres
Centrarchus macropterus
Chaenobryttus gulosus
Cliola vigilax
Clupea chrysochloris
Cottus baird
Cyclopterus elongatus
Dorosoma cepedianum
Erimyzon sucetta oblongus
Etheostoma blennioides
Rhinichthys atronasus

OF MICHIGAN

8. REPORT OF AN EXAMINATION OF THE RIVERS OF KENTUCKY—Continued

Page.

Species enumerated in lists—Continued.
- Micropterus salmoides ...253, 258, 261, 263, 266, 273, 274, 280 284, 285, 286
- Minytrema melanops ... 257
- Moxostoma anisurum ... 286
  - breviceps ... 286
  - duquesnei ..251, 253, 256, 262, 266, 268, 269, 270, 274, 278, 283, 285, 286
  - velatum ... 268
- Notemigonus chrysoleucus ...271, 274
- Notropis arge ...258, 279
  - ariommus ...251, 257, 278, 283
  - atherinoides ...251, 253, 258, 261, 262, 266, 268, 272, 274, 279, 284, 285, 286
  - coccogenis ... 284
  - deliciosus .251, 257, 261, 266, 269, 272, 278, 283, 285, 286
  - dilectus ...257, 266, 269, 279, 283, 285
  - galacturus ... 266
  - jejunus ...262, 272, 284, 286
  - megalops ...251, 253, 257, 261, 262, 266, 268, 269, 272 278, 283, 285
  - spectrunculus ...266, 270
  - telescopus ... 258
  - umbratilis ardens ... 257
    - cyanocephalus .. 251, 253, 261, 266, 268, 270, 272, 279
  - whipplei ...251, 253, 257, 262, 266, 268, 269, 274, 278, 283, 285, 286

Page.

Species enumerated in lists—Continued.
- Noturus eleutherus ... 256
  - flavus ... 285
  - gyrinus ...253, 270, 274
  - miurus ...251, 253, 256, 270, 278, 283, 286
- Opsopœodus bollmani ... 272
  - emiliæ ...263, 271, 274
- Phenacobius uranops ...258, 266
- Pimephales notatus 251, 253, 257, 261, 262, 266, 268, 269, 270, 272, 274, 278, 283, 285, 286
- Pomoxis annularis ...258, 261, 271, 273, 274, 286
  - sparoides ...273, 274
- Rhinichthys atronasus ... 268
- Roccus chrysops ...263, 268
- Semotilus atromaculatus ...251, 258, 266, 270, 280, 284
- Stizostedion canadense ...284, 286
  - vitreum ...260, 263, 268, 284, 286
- Zygonectes notatus ...251, 258, 261, 263, 271, 273, 274

Straight Creek ... 265
Table of distribution of fishes ...287–288
Tradewater River ...261–262
Triplet Creek ... 285
Troublesome Creek ... 277
Upper Cumberland River ...263–267
Upper Green River ...254–260
Upper Kentucky River ...275–281
Upper Tennessee River ... 269
Whitley County, fishes collected by D. S. Jordan in 268

9. THE RIVERS OF CENTRAL FLORIDA TRIBUTARY TO THE GULF OF MEXICO, WITH LISTS OF FISHES INHABITING THEM.

Alligator Creek ... 296
Alligator River ...293–294
Charlie Apopka ... 295
Galliger Drain ... 298
Hillsboro River ...298–299
Joshua Creek ... 295
Little Withlacoochee River ... 299
Mill Creek ... 298
New River ... 301
Oak Creek ... 296
Peace River ...295–297
Pemberton Creek ... 298
Pond Creek ... 300
Rettger, Louis J. ... 293
Sampson Creek ... 301
Santa Fé River ...301–302
Species enumerated in lists:
- Achirus fasciatus ...294, 297
- Ameiurus natalis ...298, 300, 301
  - nebulosus ... 296
- Aphredoderus sayanus ... 302
- Chænobryttus gulosus ...294, 297, 298, 300, 302
- Elassoma evergladei ...299, 300, 302
- Erimyzon sucetta ...296, 298, 300, 301
- Etheostoma quiescens ...294, 297, 299, 300, 302
- Fundulus ocellaris ... 300

Species enumerated in lists—Continued.
- Fundulus seminolis ... 297
- Gerres gula ... 294
- Gambusia patruelis ...294, 296, 298, 300, 301
- Heterandria ommata ... 302
- Jordanella floridæ ...294, 296, 298, 300
- Labidesthes sicculus ...294, 297, 298
- Lepisosteus platystomus ... 298
- Lepomis holbrooki ...297, 298, 300
  - megalotis ...297, 298, 302
  - pallidus ...297, 298, 300, 302
  - punctatus ...294, 297, 302
- Lucania goodei ...294, 296, 300
- Micropterus salmoides ...297, 298
- Mollienesia latipinna ...296, 300
- Notemigonus chrysoleucus bosci ...294, 296
- Notropis metallicus ... 300
  - roseus ...294, 296, 298, 300, 301
- Noturus gyrinus ... 301
  - leptacanthus ... 301
- Opsopœodus bollmani ...294, 296, 300
- Zygonectes chrysotus ...296, 300, 301
  - notti ... 301

Streams examined, list of ... 293
Withlacoochee River ...299, 300

II. THE STREAMS AND FISHES OF CLINTON COUNTY, KENTUCKY.

Albany Branch 288
Clinton County, physical characteristics 287
Illwill Creek 288
Indian Creek 289
Northern water system, principal streams 288, 289
Sand Lick Creek 289
Southern water system, principal streams 289
Species enumerated in list:
Ambloplites rupestris 291
Ameiurus nebulosus 291
Anguilla chrysypa 291
Campostoma anomalum 291
Catostomus nigricans 291
teres 291
Chrosomus erythrogaster 291
Clupea chrysochloris 291
Ethcostoma blennioides 291
caprodes 291
flabellare 291
olmstedi 292
rufilineatum 291
Fundulus catenatus 291
Species enumerated in list—Continued.
Hyborhynchus amblops 291
notatus 291
Ictalurus punctatus 291
Ictiobus cyprinella 291
Leptostoma aneurum 291
Leptotis megalotis 291
Notropis galacturus 291
hircinus 291
megalops 291
telescopus 291
umbratilis cyanocephalus 291
whipplei 291
Pimephales notatus 291
Polyodon spathula 291
Rhinichthys atronasus 291
Semotilus atromaculatus 291
Stizostedion canadense 292
Spring Creek 290
Wilds Creek 290
Wolf River 290

III. AN INVESTIGATION OF THE COAST WATERS OF SOUTH CAROLINA WITH REFERENCE TO OYSTER-CULTURE.

Abercrombie Creek 314
Anchor Creek 312
Anomalies, special table of 300
Arrowroot River 311
Ashley River 320
Bass Creek 316, 317
Battery Creek 313, 314
Beaufort River 1, 3
Bennett Creek 305
Bird Creek 318
Bohicket Creek 317, 318
Boone Hall 312
Broad Creek 308
Brockington Creek 314
Bull Bay 324, 325
Bull Creek 320
Bull Island 322
Bulls Bay 322, 323
Cainhoy Creek 320
Capers Island 322
Capers Island, character of oysters on 322
Charleston Harbor 321
Charleston Light 321
Charleston, oysters on wharves at 321
Charleston, water supply of 321
Chisolm Creek 316
Church Creek 316
Clam Creek 316
Clark Sound 305
Clouter Creek 316
Coast Line Canal 316
Cole Creek 316
Combahee River 314
Cooper River 320
Copahee Creek 316
Cove Inlet 316
Cow Pen Bay 322
Creek, Abercrombie 314
Anchor 312
Bass 316, 317
Battery 313, 314
Bennett 305
Bird 318
Bohicket 317, 318
Broad 308
Brockington 314
Bull 320
Capers Island, character of oysters on 322
Charleston, oysters on wharves at 321
Charleston, water supply of 321
Chisolm 316
Church 316
Clam 316
Clark Sound 305
Clouter 316
Coast Line Canal 316
Cole 316
Cove Inlet 316
Cow Pen Bay 322
Goat Island 322
Griffin, John 316, 317
Harbor River 314
Introductory note 303-305
Jericho Creek 313-314
Jones Creek 327
Kendall, W. C. 303
Kiawah River 319
Leadenwah Creek 318
Limehouse Creek 319-320
Long Island Creek 322
Mackay Creek 309-310
Magwood Brothers 324
Map, River 309
Marsh Island Creek 318
Meeting House Creek 322-323
Mendenhall, W. C. 305
Mingo River 330
Morgan River 315
Murphy Bar 325
Native Oyster and the oyster 329
New River 307-308
North Edisto River 317
North Island 326
Okatee River 311
Old Map, Creek 327-328
Oyster Bar 325-326
Oysters bearing waters of South Carolina, characteristics of 306
Palmetto Creek 314
Pierce Creek, Robert 303
Pocotaligo River 312
Port Royal Sound 310
Screw Creek 326
Schooner Creek 319-320
Silk Creek 310
South Edisto River 316
Spec, Jones Island quoted 306
Sterling Creek 314

UNIVERSITY OF MICHIGAN

11. AN INVESTIGATION OF THE COAST WATERS OF SOUTH CAROLINA WITH REFERENCE TO OYSTER-CULTURE—Continued.

Steamboat Creek 317
Stono Inlet 319
Stono River 319
St. Helena Sound 316
Story River 314
St. Pierre Creek 316
Sullivan Island Narrows 322
Swinton, Thomas 322
Togodo Creek 318
Town Creek 326
Townsend River 318
Wadmelaw River 318, 319
Wando River 321
Water area surveyed 304
Whale Branch 312
Winslow, Lieut. Francis 303
Winyaw Bay 325
Wright River 307

12. OBSERVATIONS ON THE HATCHING OF THE YELLOW PERCH.

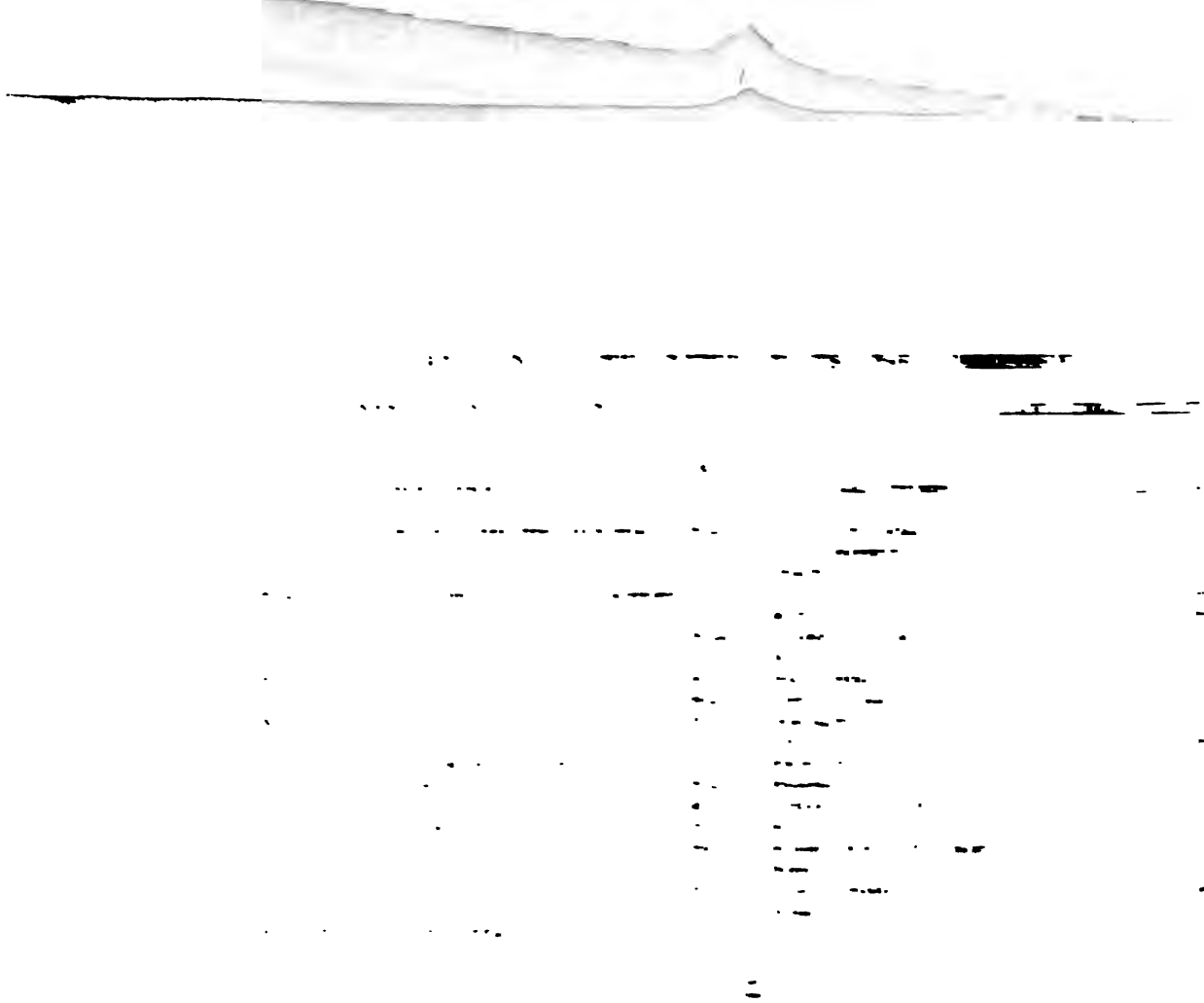
Date of spawning 331
Description of spawn 332
General directions for hatching 334
Egg production, table of 333
Fry released 333
Parent fish obtained 331
Parent fish, small cost of 331
Temperature of water during hatching 331, 333

13. BIOLOGY OF THE OYSTER-GROUNDS OF SOUTH CAROLINA.

Analyses of South Carolina oyster-bed waters 353, 357, 361
Animal element of oyster food 347
Battle, John D 335, 339, 345
Colson, C. Bunting 343, 352, 355
Composition of water at different depths 343–344
Density of water preventing oyster fry from settling 340–341
Diatoms 347–348
Enemies of the oyster 352
Food of South Carolina oyster 345–350
General character of the bottom and its life 345
General summary of report 355
Messmates and enemies; spawning season 351–352
Oyster cluster and its origin 337–338
Oyster crab, relation to its host 351–352
Oyster food, amount occurring in South Carolina waters, as determined by analysis 348–349
Oyster food, component organisms 346
Oyster ledges and flats 335–338
Oysters detached from raccoon ledges 339
Oyster spat, absence in deep water 340–344
Phosphate-dredging, effect upon oyster water 354
Pine pollen 348
Plant element of oyster food 347–348
Platt, Robert 340, 355
Ryder, John A 338, 342, 346, 351
Silt suspension 341–343
Spawning season 352
Swimming embryo, fixation of 341
Time of feeding of the oyster 350
Verrill, A. E 351
Works and authors consulted in preparing report 356

14. THE PRESENT METHODS OF OYSTER-CULTURE IN FRANCE.

Advantages for oyster-culture in the United States 363
Barbey, M., minister of marine of France 364
Bouchon-Brandeley, M., inspector-general of fisheries of France 364, 374
Bouquet (collector) 370
Camion (collector) 370
Claires: Special processes, such as "greening" or preparing for transportation 378–380
Coating collectors with cement (chaulage) 371
Collectors for oyster fry 368–374
Coste, M 364
Dasté, M 369, 371, 375, 377
De Bon, M 364, 368
Détroqnage and transportation 372–374
De Saint-Sauveur, Mme 372, 373
Élevage, or the growing of oysters for market 374–377
Flat and Portuguese oysters, compared 366
Gabarét (collector) 369
General conclusions of report 382–384
Introduction to report 363–364
Leroux, M 371, 375
Martin, M 371, 375
Mushroom (collector) 370
Natural oyster banks and dredging 367
Oyster-culture and its branches 368–381
Oyster in France 365–367
Placing and management of collectors 371–372
Planche (collector) 370
Portuguese oyster 381
Production in closed ponds 372–374
Production, or the raising of seed oysters, and kinds of collectors 368–374
Reservation by Government of oyster-bearing tracts 374
Spat-collectors 368, 374
Species and characteristics of the oyster in France 365–366
Tiles 368–370
Waters of oyster-grounds of French coast, table of densities 384
Works relating to French oyster-culture, list of 385–388



UNIVERSITY OF MICHIGAN

UNIVERSITY OF MICHIGAN

5. FISHERIES OF THE NEW ENGLAND STATES—Continued.

Page.
Tabular statements—Continued.
106. Relative quantity and value of yield in each principal form of apparatus of capture employed in the shore fisheries of Rhode Island in 1889..... 163
107. Showing by counties certain averages and percentages of the shore fisheries of Rhode Island in 1889 163
108. Showing by counties the percentage of the value of each species to the total yield of the shore fisheries of Rhode Island in 1889..... 164
109. Extent of menhaden industry of Rhode Island.... 164
110. Persons employed in Connecticut fisheries..... 165
111. Apparatus and capital employed in Connecticut.. 165
112. Products of Connecticut fisheries..... 166
113. Showing by counties the number and nationality of persons engaged in the vessel fisheries of Connecticut in 1889..... 167
114. Showing by counties the number, value, and net tonnage of vessels and the quantity and value of apparatus of capture employed in the vessel fisheries of Connecticut in 1889 167
115. Showing by counties the yield of the vessel fisheries of Connecticut in 1889..... 168
116. Showing by counties certain average figures for vessels employed in the fisheries of Connecticut in 1889..... 168
117. Summary by customs districts of the vessel fisheries of Connecticut in 1889 168
118. Showing by species and customs districts the yield of the vessel fisheries of Connecticut in 1889.... 169
119. Showing by customs districts the average tonnage, value, crew, and stock of vessels employed in the fisheries of Connecticut in 1889 169
120. Showing by apparatus and species the yield of the vessel fisheries of Connecticut in 1889, exclusive of molluscan, crustacean, and mammalian fisheries 170

Page.
Tabular statements—Continued.
121. Number of vessels engaged in each fishery in Connecticut in 1889, with tonnage, value, and number of crew 170
122. Showing by fisheries and species the yield of the vessel fisheries of Connecticut in 1889 171
123. Showing by counties the number of persons engaged in the shore fisheries of Connecticut in 1889 172
124. Showing by counties the apparatus employed in the shore fisheries of Connecticut in 1889..... 172
125. Showing by counties and species the yield of the shore fisheries of Connecticut in 1889 172
126. Showing by counties and apparatus the yield of the shore fisheries of Connecticut in 1889....173–174
127. Relative quantity and value of yield in each principal form of apparatus of capture employed in the shore fisheries of Connecticut in 1889..... 174
128. Showing by counties certain averages and percentages of the shore fisheries of Connecticut in 1889 175
129. Showing by counties the percentage of value of each species to total yield of shore fisheries of Connecticut in 1889 175
130. Extent of menhaden industry of Connecticut in 1889 176
Vessel fisheries, relative importance of..... 85
Vessel fisheries of Connecticut.....166–171
Vessel fisheries of Maine.....95–104
Vessel fisheries of Massachusetts.....126–135
Vessel fisheries of New Hampshire 121–122
Vessel fisheries of Rhode Island.....155–159
Washington treaty, effects of abrogation.....83, 108, 109
Weights of products, explanation of system 74
Whiting, utilization of..... 82

6. THE FISHERIES OF LAKE ONTARIO.

Alewife.....187–192
Atlantic salmon.....195–202
Bait fishes.....210–211
Calico bass 209
Canadian import trade.....183–185
Cape Vincent customs district 184
Commercial fishes, notes on.....185–209
Deficient food, effect on alewives.....191–192
Dominion of Canada, whitefish planted by 205
Fishes referred to, common names:
Alewife.....187–192, 211, 214
Atlantic salmon.....195–202, 214
Bait fishes 210–211
Black bass, large-mouthed 214
small-mouthed..... 215
Bloater..... 207
Bloater whitefish..... 207
Blue pike..... 208
Blunt-nosed minnow 211
Branch herring..... 214
Bullhead 213
Burbot 215
Calico bass 209, 214
Carp, leather 213
Carp mullet 213
Fishes referred to, common names—Continued.
Chub.....211, 212
Cisco.....206, 214
Ciscoette..... 207
Cusk, fresh-water..... 215
Dace 211
Dogfish 211, 213
Dory 215
Drum, fresh-water 215
Fallfish 211
Fresh-water cusk..... 215
drum..... 215
Gaspereau 187
Gizzard 214
Grass bass 209
Herring, branch..... 214
lake 206, 214
Horned dace.....211, 214
Hornyhead..... 211
Hoy's whitefish 206, 207, 214
Johnny darter..... 211
Lake herring.....206, 214
moon-eye..... 214
trout 202–203, 214
Lawyer..... 215

UNIVERSITY OF MICHIGAN
3 9015 04582 6289

6. THE FISHERIES OF LAKE ONTARIO—Continued.

Page.

Oath, form of, taken by importers 183
Oswego customs district 184
Persons referred to or quoted:
Ainsworth, W 194
Baird, Prof. Spencer F., on salmon 198, 199
shad 193
Bean, Dr. T. H., on alewife 188
Collins, Capt. J. W 177
Dolley, Prof. Charles S., on alewife 192
Douglass, Earl S., on salmon 198
Doyle, Edward P 203
Edmunds, Dr. M. C., on salmon 198, 199, 200
Gilbert, Dr. Charles H 211
Green, Seth, on alewife 188
salmon 198, 200
shad fry planted by 193
Green, Seth, jr., on alewife 188
Henshall, Dr. J. A., on black bass 215
Horton, E. B., on salmon 198
Ingersoll, B. E., on salmon 196, 201
salmon trout 203
lake trout 203
Jordan, Prof. D. S., on Hoy's whitefish 207
Kirtland, Prof. J. P., on strawberry bass 209
Learned, Charles, on salmon 197
McDonald, Hon. Marshall, on alewife 191
salmon 200, 202
Lake Ontario fisheries 213
Matheson, H. L 194
Milner, J. W., on sturgeon 186
Nelson, W. E., on salmon 197
Norris, Thaddeus, on salmon 198
Ryder, Prof. John A., on sturgeon 186

Page.

Persons referred to or quoted—Continued.
Strowger, Charles H., on alewife 189, 192
ling 215
Wilmot, S., on alewife 192
Wilson, John S., on salmon 197
Physical characteristics of Lake Ontario 178–179
Pike perches 208–209
Prefatory note 177–178
Present and past condition of Lake Ontario fisheries 179–183
Rochester Post-Express quoted 191, 192
Salmon trout 202–203
Shad 193–195
Statistics of Lake Ontario fisheries 179–183
Storms, effect of, on alewives 192
Strawberry bass 209
Sturgeon 185–187
Tabular statements:
Capital invested 180
Comparative statistics for 1880 and 1890 183
Importations from Canada 184
Persons employed 180
Products 181
Shad fry planted 193
Whitefish fry planted 205
Wholesale prices of fish 182
Tariff law, effects of 184
Temperature of water, effect of, on alewives 192
United States Fish Commission, investigation by 177
station of, at Put-in-Bay 206
sturgeon hatching by 187
whitefish planted by 205
Whitefish, common 204–206
Whitefishes, lesser 206–207

7. REPORT UPON THE FISHES OF IOWA.

Big Sioux River 246
Boyer River 248
Boynton, E. P 217
Burnett, Prof. Percy B 217
Call, R. E 217
Cedar River and tributaries 230–236
Clear Lake 237
Des Moines River and tributaries 222–225
Drainage of the Mississippi River 220–244
Drainage of the Missouri River 245–248
Gilbert, Prof. C. H 217
Iowa River 227–229
Ives, C. J 217
Jackson, W. T 217
Jordan, Prof. David S 217
Maquoketa River 240–241
Mississippi River 220–222
Missouri River 245
Nutting, C. C 217
Shaw, B. F 217, 219
Silver Lake 247
Skunk River 225–226
Soldier River 247
Species enumerated:
Acipenser rubicundus 221
Ambloplites rupestris 222, 224, 226, 235, 237, 239, 246
Ameiurus melas 221, 223, 225, 228, 232, 237, 238, 240, 242, 244, 247, 248
natalis 232

Species enumerated—Continued.
Ameiurus nebulosus 221, 225, 232, 238
nigricans 221
Amia calva 221, 228, 232
Ammocœtes branchialis 225, 228, 231
Anguilla chrysypa 222, 224, 229, 235
Aplodinotus grunniens 222, 236, 246
Campostoma anomalum 223, 225, 228, 233, 240, 242, 243, 244
Carpiodes velifer 221, 223, 225, 228, 232, 238, 245, 246
Catostomus nigricans 223, 225, 228, 232, 238, 240, 242, 243
teres 221, 223, 225, 228, 232, 238, 240, 242, 243, 244, 246, 248
Chænobryttus gulosus 222, 229, 235
Chrosomus erythrogaster 223, 225, 228, 233, 240, 242, 243
Cliola vigilax 221, 223, 226, 228, 233, 239, 244
Clupea chrysochloris 221
Cottus bairdi 242, 243
Couesius dissimilis 229
Cycleptus elongatus 221
Dorosoma cepedianum 221, 234, 239, 245, 246
Erimyzon sucetta 232
Etheostoma aspro 225, 226, 229, 236, 239, 241, 242, 246
caprodes 224, 236
cœruleum 226, 236, 239, 243
evides 236
fiabellare 225, 229, 236, 237, 239, 241, 242, 243
iowæ 225, 226, 229, 236
jessiæ 225, 226, 236
microperca 236, 241

7. REPORT UPON THE FISHES OF IOWA—Continued.

Page.

Species enumerated—Continued.
Etheostoma nigrum .224, 226, 229, 236, 237, 239, 241, 242, 243, 244, 246, 248
pellucidum clarum.....222, 224, 236, 239
phoxocephalum.....222, 225, 236
shumardi 222
zonale 225, 226, 236, 241, 242, 246
Fundulus zebrinus.....224, 229, 235, 237, 246, 247
Eucalia inconstans.....235, 241, 242, 243, 244
Hiodon alosoides 245, 246
tergisus 234
Hybognathus nubila.....228, 233, 238, 242
nuchalis 221, 223, 225, 228, 233, 238, 240, 245, 246, 247
nuchalis placita..... 223
Hybopsis dissimilis 234, 239, 242
gelidus..... 245
kentuckiensis.....224, 226, 229, 234, 239, 241, 242, 243, 244, 246
storerianus 221, 224, 229, 234, 239, 242
Ictalurus furcatus..... 221
punctatus.....221, 223, 225, 228, 232, 238, 245, 246
Ictiobus bubalus 221
cyprinella.....221, 225, 238
sp..... 242
urus 221
Labidesthes sicculus.....222, 224, 226, 235, 237, 239
Lepisosteus osseus.....221, 223, 228, 232, 238
platystomus..... 221
Lepomis cyanellus 222, 224, 226, 229, 235, 239, 241, 242, 246, 247, 248
gibbosus 222, 235, 239
holbrooki 220, 235
humilis 222, 224, 226, 235, 246, 248
macrochirus 235
megalotis 222, 224, 229, 235, 241, 244, 247
pallidus.....222, 224, 226, 229, 235, 237, 239, 241
Leptops olivaris.....221, 232
Lota lota maculosa 222
Lucius lucius 222, 224, 226, 229, 235, 237, 239, 248
masquinongy.....222, 226
vermiculatus.....221, 224, 235
Micropterus dolomieu....222, 224, 226, 236, 237, 239, 241, 242
salmoides.....222, 224, 226, 229, 236, 237, 239
Minytrema melanops 221, 225, 228
Morone interrupta 222
Moxostoma anisurum 223, 232
aureolum 225
duquesnei..... ....221, 223, 225, 228, 232, 238, 240, 242, 244, 246
sp..... 225
Notemigonus chrysoleucus 221, 224, 226, 234, 237, 239, 241, 246, 247

Page.

Species enumerated—Continued.
Notropis anogenus 233
ardens.....224, 226, 228, 234, 239, 240, 242, 244
atherinoides 229, 231, 246
cayuga 223, 226 228, 233, 239, 240, 246
deliciosus 221, 223, 226, 228, 233, 239, 240, 242, 244, 246, 248
dilectus.....221, 224, 226, 229, 234, 239, 240, 242, 243, 244, 245, 246
gilberti.221, 223, 226, 228, 233, 239, 240, 242, 247, 248
heterodon 223, 226, 228, 233, 240, 242, 247
hudsonius 237, 246
jejunus 221, 234, 242
lutrensis.....223, 248
megalops.....224, 226, 228, 233, 239, 240, 242 243, 244, 246, 247, 248
topeka.....223, 228, 233, 246, 248
whipplei 221, 223, 226, 228, 233, 239, 240, 242, 244, 246
Noturus exilis.....223, 225
flavus.....232, 245, 246
gyrinus 221, 223, 225, 228, 232, 246
Perca flavescens.....222, 225, 229, 236, 237, 246, 247
Percopsis guttatus 246, 248
Petromyzon concolor.....221, 223, 228, 231
Phenacobius mirabilis.....224, 226, 229, 234, 248
Phoxinus elongatus 243
Pimephales notatus.....221, 223, 226, 228, 233, 237, 238, 240, 242, 243, 244, 246, 247
promelas.....223, 226, 233, 238, 240, 242 243, 244, 247, 248
Placopharynx carinatus... 223
Platygobio gracilis 245
Polyodon spathula 221, 228, 231, 245
Pomoxis annularis 222, 224, 229, 235, 239
sparoides 222, 226, 229, 235, 237, 239
Rhinichthys atronasus.....224, 234, 240, 242, 243, 244
cataractæ 244
Roccus chrysops 222, 246, 247
Salvelinus fontinalis 221, 235
Scaphirhynchus platyrhynchus 221, 231, 245
Semotilus atromaculatus 221, 224, 226, 234, 241, 242, 243, 247, 248
Stizostedion canadense.....222, 236, 246
vitreum 222, 229, 236, 237, 246
Umbra limi.....229, 235
Zygonectes dispar..... 235
notatus 224, 226, 229, 235, 239
Turkey River 241-242
Upper Iowa River..... 244
Wapsipinicon River..... 238-239
Yellow River..... 243
White, Joseph 217

8. REPORT OF AN EXAMINATION OF THE RIVERS OF KENTUCKY.

Bayou de Chien 273-274
Beaver Creek..... 255
Big Barren River..... 254
Big Creek 276
Big Sandy River.....281-284
Blaine Creek 282
Bull Creek 276
Chambers, Charles O..... 249
Clear Creek 264
Clinton County, fishes of..... 267
Coon Creek..... 282
Cumberland River.....264-265
Cutshin Creek..... 277
Drake Creek 254
Gilbert, Charles H 249
Goose Creek..... 275
Green River.....255-256
Hector Creek..... 275

8. REPORT OF AN EXAMINATION OF THE RIVERS OF KENTUCKY—Continued.

Page.

Henshall, James A. 249
Horse Creek 275
Introduction 249–250
Island Creek 282
John Creek 282
Jordan, David S. 249
Kirsch, Philip H. 249
Left Troublesome Creek 277
Levisa Fork 282
Licking River 285–286
Little Barren River 255
Little Rockcastle River 264
Little Sandy River 286
Lower Cumberland River 262–263
Lower Green River 252–254
Lower Tennessee River 268
Mayfield Creek 270–271
McDonald, Marshall 249
Middle Fork 276
Monical, Hiram W. 249
North Fork 277
Obion River 272–273
Pitman Creek 256
Pond Creek 252
Powell River 269
Redbird Creek 275
Richland Creek 265
Right Fork of Beaver Creek 281
River basins, classification of 250
Robinson Creek 281
Rockcastle River 264
Rolling Fork of Salt River 250–251
Rough Creek 252
Shelby Creek 281
Smoky Fork 265
Species enumerated in lists:
Acipenser rubicundus 262, 268
Ambloplites rupestris 258, 266, 268, 269, 280, 284, 286
Ameiurus natalis 256, 268, 270
nebulosus 256, 266, 270, 274
Amia calva 274
Anguilla chrysypa 261, 266, 274
Aphredoderus sayanus 253, 271, 273, 274
Aplodinotus grunniens 251, 254, 260, 263, 268, 273, 274
Campostoma anomalum 251, 253, 257, 261, 262, 266, 268, 269, 278, 283, 285, 286
Chrosomus erythrogaster 266, 268
Carpiodes carpio 251, 261
difformis 262, 272, 283, 286
velifer 268, 270, 272, 278, 283
Catostomus nigricans 251, 253, 257, 261, 262, 266, 268, 269, 270, 278, 283, 285
teres 266, 268, 270, 278
Centrarchus macropterus 271
Chænobryttus gulosus 253, 271, 273, 274
Cliola vigilax 251, 262, 283, 286
Clupea chrysochloris 286
Cottus bairdi 260
Cycleptus elongatus 262
Dorosoma cepedianum 251, 253, 263, 268, 273, 274, 284, 286
Erimyzon sucetta oblongus 261, 266, 270
Ericymba buccata 251, 266, 279, 284, 285, 286
Etheostoma asprellus 259
aspro 254, 259, 262, 263, 267, 268, 269, 271, 273, 274, 281, 284

Page.

Species enumerated in lists—Continued.
Etheostoma blennioides 251, 259, 267, 268, 280, 284, 286
camurum 260, 267
caprodes 251, 253, 259, 263, 267, 268, 269, 273, 274
cœruleum 251, 254, 260, 267, 281, 284, 286
copelandi 253, 259
cumberlandicum 268
cymatotænia 260
evides 260
flabellare 260, 281, 284, 286
fusiforme 262, 271, 274
histrio 253
macrocephalum 259, 284
maculatum 267, 286
microperca 260
nigrum 253, 258, 262, 268, 271, 274, 280, 284, 286
obeyense 267
ouachitæ 254, 273
phoxocephalum 251, 254, 259, 262, 263, 267, 271, 284
pellucidum 251, 253, 259, 263, 267, 269, 280, 284, 286
rufolineatum 260
sagitta 268
scierum 260, 286
simoterum 260, 267, 280
shumardi 253, 263, 273
spilotum 280
stigmæum 260, 267
susannæ 268
variatum 280, 286
virgatum 260, 267
zonale 251, 260, 267, 281, 284, 286
Fundulus catenatus 258, 263, 266, 269
Gambusia patruelis 263, 273
Hiodon alosoides 251, 263
selenops 251, 258
Hybognathus nuchalis 253, 257, 262, 268, 270, 272, 274, 283, 286
Hybopsis amblops 251, 253, 258, 261, 266, 269, 270, 279, 284, 285
dissimilis 251
hyostomus 258, 284, 285
kentuckiensis 253, 258, 266, 269, 279, 284, 285
storerianus 251, 253, 263, 268, 274, 286
watauga 258, 269, 279
Ictalurus punctatus 251, 253, 256, 262, 268, 270, 272, 274, 278, 285, 286
Ictiobus bubalus 256, 262, 269, 274
Labidesthes sicculus 253, 258, 261, 263, 268, 269, 271, 273, 274, 280, 284, 285, 286
Lagochila lacera 266
Lepisosteus osseus 256, 261, 262, 268, 269, 272, 278, 286
platystomus 261, 268, 274
Leptops olivaris 251, 256, 266
Lepomis cyanellus 253, 263, 266, 268, 271, 284, 285
garmani 266, 274
heros 274
macrochirus 261, 268, 273
megalotis 251, 253, 258, 261, 263, 266, 268, 269, 271, 273, 274, 280, 284, 285, 286
pallidus 253, 258, 261, 263, 266, 274, 284, 285, 286
Lucius vermiculatus 271, 273, 274, 285
Micropterus dolomieu 251, 253, 258, 261, 263, 266, 268, 269, 273, 274, 280, 284, 285, 286

8. REPORT OF AN EXAMINATION OF THE RIVERS OF KENTUCKY—Continued

Page.

Species enumerated in lists—Continued.
Micropterus salmoides ...253, 258, 261, 263, 266, 273, 274, 280 284, 285, 286
Minytrema melanops ... 257
Moxostoma anisurum ... 286
breviceps ... 286
duquesnei ..251, 253, 256, 261, 262, 266, 268, 269, 270, 274, 278, 283, 285, 286
velatum ... 268
Notemigonus chrysoleucus ...271, 274
Notropis arge ...258, 279
ariommus ...251, 257, 278, 283
atherinoides ...251, 253, 258, 261, 262, 266, 268, 272, 274, 279, 284, 285, 286
coccogenis ... 284
deliciosus .251, 257, 261, 266, 269, 272, 278, 283, 285, 286
dilectus ...257, 266, 269, 279, 283, 285
galacturus ... 266
jejunus ...262, 272, 284, 286
megalops ...251, 253, 257, 261, 262, 266, 268, 269, 272 278, 283, 285
spectrunculus ...266, 279
telescopus ... 258
umbratilis ardens ... 257
cyanocephalus.. 251, 253, 261, 266, 268, 270, 272, 279
whipplei ...251, 253, 257, 262, 266, 268, 269, 274, 278, 283, 285, 286

Page.

Species enumerated in lists—Continued.
Noturus eleutherus ... 256
flavus ... 285
gyrinus ...253, 270, 274
miurus ...251, 253, 256, 270, 278, 283, 286
Opsopœodus bollmani ... 272
emiliæ ...263, 271, 274
Phenacobius uranops ...258, 266
Pimephales notatus 251, 253, 257, 261, 262, 266, 268, 269, 270, 272, 274, 278, 283, 285, 286
Pomoxis annularis ...258, 261, 271, 273, 274, 286
sparoides ...273, 274
Rhinichthys atronasus ... 268
Roccus chrysops ...263, 268
Semotilus atromaculatus ...251, 258, 266, 270, 280, 284
Stizostedion canadense ...284, 286
vitreum ...260, 263, 268, 284, 286
Zygonectes notatus ...251, 258, 261, 263, 271, 273, 274
Straight Creek ... 265
Table of distribution of fishes ...287–288
Tradewater River ...261–262
Triplet Creek ... 285
Troublesome Creek ... 277
Upper Cumberland River ...263–267
Upper Green River ...254–260
Upper Kentucky River ...275–281
Upper Tennessee River ... 269
Whitley County, fishes collected by D. S. Jordan in 268

9. THE RIVERS OF CENTRAL FLORIDA TRIBUTARY TO THE GULF OF MEXICO, WITH LISTS OF FISHES INHABITING THEM.

Alligator Creek ... 296
Alligator River ...293–294
Charlie Apopka ... 295
Galliger Drain ... 298
Hillsboro River ...298–299
Joshua Creek ... 295
Little Withlacoochee River ... 299
Mill Creek ... 298
New River ... 301
Oak Creek ... 296
Peace River ...295–297
Pemberton Creek ... 298
Pond Creek ... 300
Rettger, Louis J. ... 293
Sampson Creek ... 301
Santa Fé River ...301–302
Species enumerated in lists:
Achirus fasciatus ...294, 297
Ameiurus natalis ...298, 300, 301
nebulosus ... 296
Aphredoderus sayanus ... 302
Chænobryttus gulosus ...294, 297, 298, 300, 302
Elassoma evergladei ...299, 300, 302
Erimyzon sucetta ...296, 298, 300, 301
Etheostoma quiescens ...294, 297, 299, 300, 302
Fundulus ocellaris ... 300

Species enumerated in lists—Continued.
Fundulus seminolis ... 297
Gerres gula ... 294
Gambusia patruelis ...294, 296, 298, 300, 301
Heterandria ommata ... 302
Jordanella floridæ ...294, 296, 298, 300
Labidesthes sicculus ...294, 297, 298
Lepisosteus platystomus ... 298
Lepomis holbrooki ...297, 298, 300
megalotis ...297, 298, 302
pallidus ...297, 298, 300, 302
punctatus ...294, 297, 302
Lucania goodei ...294, 296, 300
Micropterus salmoides ...297, 298
Mollienesia latipinna ...296, 300
Notemigonus chrysoleucus bosci ...294, 296
Notropis metallicus ... 300
roseus ...294, 296, 298, 300, 301
Noturus gyrinus ... 301
leptacanthus ... 301
Opsopœodus bollmani ...294, 296, 300
Zygonectes chrysotus ...296, 300, 301
notti ... 301
Streams examined, list of ... 293
Withlacoochee River ...299, 300

5. FISHERIES OF THE NEW ENGLAND STATES—Continued.

Page.

Shore industries of Rhode Island 164
Smelt fishery of Maine 109
Smoked-herring industry of Maine 118–119
Soft-clam fishery of Maine 109
Squid, use of, as bait 144–145
Squid, utilization of 82

Tabular statements:

1. Number of persons employed in New England fisheries in 1889 77
2. Apparatus employed and capital invested in New England fisheries in 1889 77
3. Showing, by species, the yield of fisheries of New England States in 1889 ..... 78, 79
4. Showing number and nationality of persons employed in New England vessel fisheries in 1889 .. 79
5. Showing by States and rigs the number and tonnage of vessels employed in New England fisheries in 1889 81
6. Values of various coast fisheries of New England States in 1889 81
7. Quantities, values, and percentages of fishery products taken in each kind of apparatus in New England States in 1889 83
8. Showing by States the actual and relative importance of the vessel and shore fisheries of New England in 1889 84
9. Relative importance of each of the vessel fisheries of the New England States in 1889 85
10. Certain averages and percentages for vessels employed in New England fisheries in 1889 87
11. Certain averages and percentages for the shore fisheries of the New England States in 1889 87
12. Showing for each of fifteen important species the percentage of value in each New England State to the total value of the catch in New England. 88
13. Comparative table showing number of persons employed in New England fisheries in 1880 and 1889. 89
14. Comparative table showing number and value of vessels, boats, etc., employed in New England fisheries in 1880 and 1889 89
15. Comparative table showing values of fisheries of New England States in 1880 and 1889 90
16. Extent of menhaden industry of New England States in 1889 91
17. Extent of frozen-herring trade of New England States in 1889 93
18. Number and value of frozen herring landed in New England States by Canadian vessels in 1889 93
19. Persons employed in the fisheries of Maine 94
20. Apparatus and capital employed in Maine fisheries. 94
21. Products of Maine fisheries 95
22. Showing by counties the number and nationality of men employed in vessel fisheries of Maine in 1889 96
23. Showing by counties the number and value of vessels and apparatus employed in vessel fisheries of Maine in 1889 97
24. Showing by counties the yield of vessel fisheries of Maine in 1889 97–98
25. Showing by counties certain average figures for vessels employed in fisheries of Maine in 1889 .. 99
26. Showing by counties the percentage of value of each species or product taken in the vessel fisheries of Maine in 1889 99

Page.

Tabular statements—Continued.

27. Summary by customs districts of the vessel fisheries of Maine in 1889 100
28. Showing by species and customs districts the yield of the vessel fisheries of Maine in 1889 100–101
29. Showing by customs districts the average tonnage, value, crew, and stock of vessels employed in the fisheries of Maine in 1889 102
30. Showing by apparatus and species the yield of the vessel fisheries of Maine in 1889, exclusive of the molluscan and crustacean fisheries 102
31. Number of vessels engaged in each fishery in Maine in 1889, together with their tonnage, value, and number of crew 103
32. Showing by fishing-grounds and apparatus, the catch of the mackerel fleet of Maine in 1889 103
33. Showing by fisheries and species the yield of the vessel fisheries of Maine in 1889 104
34. Showing by counties the number of persons engaged in the shore fisheries of Maine in 1889 106
35. Showing by counties the apparatus employed in the shore fisheries of Maine in 1889 106
36. Showing by counties and species the yield of the shore fisheries of Maine in 1889 107
37. Showing by counties and apparatus the yield of the shore fisheries of Maine in 1889 111–113
38. Relative quantity and value of yield in each principal form of apparatus of capture employed in the shore fisheries of Maine in 1889 113
39. Showing by counties certain averages and percentages of the shore fisheries of Maine in 1889. 114
40. Showing by counties the percentage of the value of each species to the total yield of the shore fisheries of Maine in 1889 114
41. Showing by counties the products of the canning industry of Maine in 1889 115–116
42. Summary by counties of the canning industry of Maine in 1889 116
43. Classification of employés of sardine canneries in Washington and Hancock counties, Maine, in 1889, with statement of weekly and annual wages 117
44. Number and value of supply boats employed in the sardine industry of Washington and Hancock counties, Maine, in 1889 118
45. Extent of the lobster-canning industry of Maine in 1889 118
46. Extent of the smoked-herring industry of Maine in 1889 118
47. Quantities of smoked herring prepared by fishermen and sardine-canners of Maine in 1889 119
48. Comparative table showing quantity of herring smoked in Maine in 1880, 1887, 1888, and 1889 ... 119
49. Extent of menhaden industry of Maine 119
50. Persons employed in New Hampshire fisheries ... 120
51. Apparatus and capital in New Hampshire fisheries 120
52. Products of New Hampshire fisheries 120
53. Number of vessels engaged in each fishery in New Hampshire in 1889, with tonnage, value, and number of crew 121
54. Showing by fisheries and species the yield of the vessel fisheries of New Hampshire in 1889 121
55. Showing by species the yield of the vessel fisheries of New Hampshire in 1889 122

5. FISHERIES OF THE NEW ENGLAND STATES—Continued.

Page.

Tabular statements—Continued.

56. Showing by apparatus and species the yield of the vessel fisheries of New Hampshire in 1889, exclusive of the lobster fisheries 122
57. Showing by species the yield of the shore fisheries of New Hampshire in 1889 123
58. Showing by apparatus and species the yield of the shore fisheries of New Hampshire in 1889 123
59. Persons employed in Massachusetts fisheries 124
60. Apparatus and capital employed in Massachusetts fisheries 124
61. Products of Massachusetts fisheries 125
62. Showing by counties the number and nationality of men employed in the vessel fisheries of Massachusetts in 1889 127
63. Showing by counties the number and value of vessels and apparatus employed in the vessel fisheries of Massachusetts in 1889 127
64. Showing by counties and species the yield of the vessel fisheries of Massachusetts in 1889 128–129
65. Showing by counties certain average figures for the vessels employed in the fisheries of Massachusetts in 1889 129
66. Showing by counties the percentage of value of each species or product taken in the vessel fisheries of Massachusetts in 1889 130
67. Showing by species and customs districts the yield of the vessel fisheries of Massachusetts in 1889 130–131
68. Summary by customs districts of the vessel fisheries of Massachusetts in 1889 132
69. Showing by customs districts the average tonnage, value, crew, and stock of vessels employed in the fisheries of Massachusetts in 1889 132
70. Showing by apparatus and species the yield of the vessel fisheries of Massachusetts in 1889, exclusive of molluscan, crustacean, and mammalian fisheries 133
71. Number of vessels engaged in each fishery in Massachusetts in 1889, with tonnage, value, and number of crew 133
72. Showing by fisheries and species the yield of the vessel fisheries of Massachusetts in 1889 134
73. Showing by fishing-grounds the catch of the mackerel (by apparatus), the bank cod, the Grand and Western bank fresh halibut, and the Iceland halibut fleets of Massachusetts in 1889. 135
74. Showing by counties the number of men employed in the shore fisheries of Massachusetts in 1889.. 137
75. Showing by counties the apparatus employed in the shore fisheries of Massachusetts in 1889..... 137
76. Showing by counties and species the yield of the shore fisheries of Massachusetts in 1889 137–138
77. Showing by counties and apparatus the yield of the shore fisheries of Massachusetts in 1889..139–142
78. Relative quantity and value of yield in each principal form of apparatus of capture employed in shore fisheries of Massachusetts in 1889..... 143
79. Showing by counties certain averages and percentages of shore fisheries of Massachusetts in 1889 143
80. Showing by counties the percentage of value of each species to the total yield of the shore fisheries of Massachusetts in 1889..... 145

Page.

Tabular statements—Continued.

81. Showing by counties and apparatus the quantities of fish and squid taken in the shore fisheries of Massachusetts in 1889 and sold for bait..... 145
82. Showing by counties and species the quantities of fish and squid taken in the shore fisheries of Massachusetts in 1889 and sold for bait..... 145
83. Showing by apparatus and species the quantities of fish and squid taken in the shore fisheries of Massachusetts in 1889 and sold for bait..... 145
84. Extent of wholesale fish trades and related industries of Gloucester, Mass., in 1889 148
85. Extent of wholesale fish trades of Boston, Mass., in 1889..... 149
86. Showing by fishing-grounds the quantities of fish landed at Gloucester, Mass., in 1889, by New England fishing vessels 150
87. Showing by fishing-grounds the quantities of fresh ground-fish landed at Boston, Mass., in 1889, by New England fishing vessels 153
88. Showing by fishing-grounds and months the quantities of fresh and salt mackerel landed at Boston, Mass., in 1889, by New England fishing vessels 153
89. Persons employed in Rhode Island fisheries..... 154
90. Apparatus and capital employed in Rhode Island fisheries..... 154
91. Products of Rhode Island fisheries..... 155
92. Showing by counties the number and nationality of persons employed in the vessel fisheries of Rhode Island in 1889..... 156
93. Showing by counties the number, tonnage, value, and outfits of vessels employed in the vessel fisheries of Rhode Island in 1889..... 156
94. Showing by counties the yield of vessel fisheries of Rhode Island in 1889..... 156
95. Showing by counties certain average figures for vessels employed in the fisheries of Rhode Island in 1889..... 157
96. Summary by customs districts of the vessel fisheries of Rhode Island in 1889..... 157
97. Showing by species and customs districts the yield of vessel fisheries of Rhode Island in 1889..... 157
98. Showing by customs districts the average tonnage, value, crew, and stock of vessels employed in the fisheries of Rhode Island in 1889..... 158
99. Showing by apparatus and species the yield of the vessel fisheries of Rhode Island in 1889, exclusive of the molluscan and crustacean fisheries..... 158
100. Number of vessels engaged in each fishery in Rhode Island in 1889, with tonnage, value, and number of crew 159
101. Showing by fisheries and species the yield of the vessel fisheries of Rhode Island in 1889..... 159
102. Showing by counties the number of persons engaged in the shore fisheries of Rhode Island in 1889 160
103. Showing by counties the apparatus employed in the shore fisheries of Rhode Island in 1889..... 161
104. Showing by counties and species the yield of the shore fisheries of Rhode Island in 1889..... 161
105. Showing by counties and apparatus the yield of the shore fisheries of Rhode Island in 1889..... 162